EXHIBIT C

UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

TQ DELTA, LLC, *Plaintiff,* v. **COMMSCOPE HOLDING COMPANY, INC., COMMSCOPE INC., ARRIS US HOLDINGS, INC., ARRIS SOLUTIONS, INC., ARRIS TECHNOLOGY, INC., and ARRIS ENTERPRISES, LLC** *Defendants*.	CIV. A. NO. 2:21-CV-310-JRG (Lead Case)

TQ DELTA, LLC, *Plaintiff,* v. **NOKIA CORP., NOKIA SOLUTIONS AND NETWORKS OY, and NOKIA OF AMERICA CORP.,** *Defendants*.	CIV. A. NO. 2:21-CV-309-JRG (Member Case)

OPENING EXPERT REPORT OF MARK R. LANNING ON THE INVALIDITY OF THE ASSERTED CLAIMS OF THE FAMILY 10 PATENTS (U.S. PATENT NOS. 9,154,354; 8,937,988)

TABLE OF CONTENTS

Page

I. INTRODUCTION

1. My name is Mark Lanning. I have been asked by CommScope Holding Company, Inc., CommScope Inc., ARRIS US Holdings, Inc., ARRIS Solutions, Inc., ARRIS Technology, Inc., and ARRIS Enterprises, LLC (collectively, "CommScope") and Nokia of America Corporation, Nokia Corporation, and Nokia Solutions and Networks, Oy (collectively, "Nokia") (together, "Defendants") to provide this report in connection with the above-captioned District Court action.

2. Specifically, I have been asked to give expert opinion and testimony regarding whether claim 10 of U.S. Patent No. 9,154,354 ("the '354 Patent") and claim 16 of U.S. Patent No. 8,937,988 ("the '988 Patent") are valid or invalid. I understand these patents are referred to as "the Family 10 Patents."

3. My report is based on the information that is currently available to me. My analysis is ongoing. As I discover new material, or as new material is presented to me, I may continue to review such material. As a result, I reserve the right to modify or supplement my opinions, as well as the basis for my opinions, based on the nature and content of the documentation, data, proof and other evidence or testimony that the Plaintiff or its experts may present or based on any additional discovery or other information provided to me or found by me in this matter. I also reserve the right to present exhibits and demonstratives as appropriate to help demonstrate and explain my opinions if I am asked to testify at trial.

II. BACKGROUND AND QUALIFICATIONS

4. I have summarized in this section my educational background, work experience, and other relevant qualifications. A detailed curriculum vitae showing more of my credentials is attached to this report as Appendix A. I have extensive development and network design

experience in the field of electrical and optical transmission systems, the Public Telephone Switching Network (PSTN) and cellular networks.

5. I am currently the president of two active consulting companies: Telecom Architects, Inc. and Reticle Consulting, LLC. I have over 40 years of experience in a wide variety of communication technologies including, but not limited to, different types of circuit-switched and packet-switched networks, cellular networks and their components, advanced cellular network based services, Public Switched Telephone Network ("PSTN") networks, local loop connection equipment including xDSL systems, VoIP networks, Advanced services that use Intelligent Networking ("Advanced Intelligent Network" or "AIN") network elements, and various signaling protocols (e.g., Signaling System 7 ("SS7") and Integrated Digital Services Network ("ISDN")).

6. Since 1995, I have also provided second generation (2G) and third generation (3G) Code Division Multiple Access (CDMA) network architecture and equipment design and implementation consulting services to companies such as Nextel. While consulting for Nextel, which has since become part of Sprint, as one of the network architects for its iDEN network, one of my responsibilities was the design for its packet switched and SONET transmission networks that were used to carry the voice and data of the cellular network and all the VoIP traffic for its dispatch network. At the time, Nextel's packet-switched network was one of the largest in the U.S.

7. I have developed software for many types of computer systems ranging in size from large scale distributed computer systems that used hundreds of computers down to a single personal computer. I have also used many different types of operating systems and programming

languages, including creating software applications that interfaced with operating systems for at least: process creation and scheduling; memory management; and inter-process communication.

8. My experience that is specifically relevant to the report began in 1985 when I was hired by Telinq, Inc. (now part of ADC Telecommunications, Inc.) as their director of software development and was later promoted to vice president of hardware and software development. Telinq initially focused on the development of high-speed digital multiplexers and analyzers for DS1, DS3 TDM transmission systems and later built SONET multiplexing equipment. This hardware consisted of multiple microprocessors for operation and control and custom designed high-speed gate arrays for the signal processing and multiplexing functions.

9. Beginning in 1991, I have been responsible for the design and implementation of multiple packet-switched networks and their required interfaces to circuit-switched networks. Examples of these networks are British Telecom in the U.K. and Nextel in the U.S.

10. I also have gained additional experience in my role as an expert regarding the implementation, configuration, installation, and operation of many of the same or similar types of accused devices that are at issue in this case. Specifically, these cases are:

- Cisco Systems, Inc. vs. Alcatel USA, Inc. and Alcatel S.A. A case regarding switching, optical (SONET) transmission and cross connect systems;
- Ciena Corporation vs. Nortel Networks Inc. A case regarding SONET, ATM, TDM and Packet Switching equipment and packet network routing methods;
- QPSX Developments 5 Pty Ltd. v. Ciena Corporation et al. A case regarding statistical multiplexing of data in high-speed digital communication networks;
- Alberta Telecommunications Research Centre (TR Labs) vs. AT&T Corporation. A case regarding TDM and SONET transmission in high-speed transmission networks; and
- Genband U.S. LLC v. Metaswitch Networks Ltd and Countersuit. Multiple cases that involved many different types of local loop and network equipment that are used in DSL, packet, voice and high-speed transmission networks.

11. In addition to my experience listed above, for at least the past ten years, in connection with my consulting work and otherwise, I have worked extensively with the 3G, 4G and 5G network standards and their associated equipment and protocols including through my study of each new release of these standards, technical books and trade publications and by evaluating the functionality of many different types of network equipment, mobile devices, baseband chipsets and literally thousands of cellular oriented patents.

12. I am a member of the Institute of Electrical and Electronics Engineers (IEEE), including the IEEE Standards Association. I am also a member of the Association for Computing Machinery (ACM). I was also a member of the American National Standards Institute (ANSI) T1 and T1X1 standard groups responsible for the definition and standardization of the Advanced Intelligent Network (AIN) and Signaling System 7 (SS7) protocol. The relevant parts of the standards created by these two groups was incorporated by the CCITT for the international SS7 standard.

13. I received a B.S. in Computer Science from SMU in 1983.

14. A complete list of cases in which I have testified at trial, hearing, or by deposition within the preceding five years is provided in my curriculum vitae, which is attached as Appendix A to my report.

15. Based on my education and experience, I believe I am qualified to render the opinions set forth here.

III. COMPENSATION

16. I am being compensated for my work on this litigation at my customary hourly rate of $550 per hour, plus reasonable expenses. I have received no additional compensation of any kind for my work on this case. No part of my compensation is dependent on the conclusions that I reach or the outcome of this case.

IV. DOCUMENTS AND OTHER MATERIALS RELIED UPON

17. My opinions are based on my years of education, research and experience, as well as my investigation and study of the relevant materials.

18. In developing my opinions, I have considered the ’988 and ’354 Patents, the file histories for the ’988 and ’354 Patents, the parties’ claim construction briefing and the Court’s claim construction order, and other documents specifically identified in this report, in their entirety, even if only portions of these documents are discussed herein as an exemplary fashion. For instance, I may rely on sections of referenced documents in addition to those referenced in this report, and may create slides or demonstratives that add detail to the matters discussed below to provide support for my opinions expressed herein. For convenience, a list of documents I have relied upon is attached hereto as Appendix B.

19. Additionally, I have considered my own experience and expertise concerning the knowledge of a person having ordinary skill in the relevant art during the timeframe of the claimed priority date of the Family 10 Patents. I have reviewed information generally available to, and relied upon by, a person having ordinary skill at the time of the alleged invention.

20. I was told to assume the time of the alleged invention is April 18, 2000, the date on which the earliest-filed provisional application, No. 60/197,727, was filed. I am also informed, however, that once an accused infringer has introduced sufficient evidence to put at issue whether there is prior art alleged to anticipate the claims being asserted, and that prior art is dated earlier than the apparent effective date of the asserted patent claim, the patentee has the burden of going forward with evidence and argument to the contrary.

V. SUMMARY OF OPINIONS

21. Claim 10 of the ’354 Patent and claim 16 of the ’988 Patent (collectively, “Asserted Claims”) are invalid as either anticipated and/or rendered obvious by the prior art cited in this report, as summarized below.

22. It is also my opinion that claim 10 of the ’354 Patent and claim 16 of the ’988 Patent are invalid as lacking written description and enablement.

23. A summary of my opinions is below:

Claim	Invalid Under	Prior Art
’354 Patent, claim 10; ’988 Patent, claim 16	35 U.S.C. § 102	Peeters
’354 Patent, claim 10; ’988 Patent, claim 16	35 U.S.C. § 103	Cai in view of Peeters
’354 Patent, claim 10; ’988 Patent, claim 16	35 U.S.C. § 103	Kapoor in view of Peeters
’354 Patent, claim 10; ’988 Patent, claim 16	35 U.S.C. §§ 102, 103	Chow
’354 Patent, claim 10; ’988 Patent, claim 16	35 U.S.C. § 103	Kapoor in view of Chow
’988 Patent, claim 16	35 U.S.C. §§ 102, 103	TNETD8000 User Guide
’354 Patent, claim 10; ’988 Patent, claim 16	35 U.S.C. §112	N/A

VI. STATEMENT OF RELEVANT LEGAL PRINCIPLES

24. I am not an attorney and will not offer opinions on the law. I have, however, an understanding of several principles concerning invalidity that I have used in arriving at my stated conclusions in this report.

25. I was requested to consider issues regarding invalidity of the Asserted Claims in this litigation and specifically address the following topics:

- the level of skill of persons who would have worked in the field around the time of the alleged inventions;
- if the claims are invalid as anticipated or obvious; and
- how, if at all, such a person would have understood the meaning and scope of these claims, and thus whether any of the claims are lack written description or enablement.

A. Presumption of Validity

26. I understand that in deciding whether to issue a patent, the U.S. Patent and Trademark Office ("USPTO") examines the patent specification, its claims, and prior art references the examiner finds or the applicant discloses to determine whether the patent application and its claims meet the requirements for patentability.

27. I understand that prior art is defined as including, but not limited to, issued patents, published patent applications, and other printed or electronic publications that were publicly accessible such that a person of ordinary skill exercising reasonable diligence could locate it. I also understand that prior art includes inventions that were known, used, in public use, or on sale in this country. I have also been told that a patent applicant can describe prior art in the "Background of the Invention" section of their patent.

28. I understand that each claim of a patent issued by the USPTO is presumed valid by law. This presumption of validity is overcome, however, if the party seeking to invalidate a claim proves invalidity by clear and convincing evidence, which I understand to mean evidence that convinces you that it is highly probable that the particular proposition is true. I understand that the clear and convincing standard is a higher burden of proof than by a preponderance of the evidence, the latter of which is something that is simply more likely than not.

29. I understand that the first step in determining whether a patent claim is invalid is to properly construe the claims. I also understand that the claims must be construed the same way in determining invalidity (or validity) and non-infringement (or infringement). I further understand that generally a claim should not be limited to a preferred or exemplary embodiment in the specification, but that in certain cases, the scope of the right to exclude may be limited by a narrow disclosure or by positions taken, such as by statements made during the prosecution

history. I also understand the claims must be supported by the specification. Also, to the extent that a patent claims priority to an earlier filed application, a patent claim is only entitled to the priority of an earlier filed application if the claims are fully supported by the disclosure in that earlier filed application.

B. <u>Claim Construction</u>

30. My opinions are based on the Court's constructions and, where the Court did not construe a term, the meaning that term would have had to a person having ordinary skill in the art in light of the specification and the prosecution history at the time of the filing of the earliest priority application.

C. <u>Prior Art</u>

31. Prior art includes any of the following items received into evidence during trial:

- any product or method that was publicly known or used by others in the United States before the date of invention;
- patents that issued more than one year before the filing date of the patent, or before the date of invention;
- publications having a date more than one year before the filing date of the patent, or before the date of invention;
- any product or method that was in public use or on sale in the United States more than one year before the patent was filed; and
- any product or method that was made by anyone before the named inventors created the patented product or method where the product or method was not abandoned, suppressed, or concealed.

32. It is my understanding that in order to qualify as a printed publication within the meaning of 35 U.S.C. § 102, a reference must have been sufficiently accessible to the public interested in the art. Whether a reference is publicly accessible is determined on a case-by-case basis based on the facts and circumstances surrounding the reference's disclosure to members of the public. A reference is considered publicly accessible if it was disseminated or otherwise made available to the extent that persons interested and ordinarily skilled in the subject matter or art exercising reasonable diligence, can locate it.

D. <u>Anticipation Under 35 U.S.C. § 102</u>

33. I have been informed by counsel and understand that a claim is invalid on the basis of anticipation (under 35 U.S.C. § 102) if a single prior art reference discloses, either expressly or inherently, each and every element of the claimed invention. If the single prior art reference fails to disclose even one claim element, it does not anticipate the claim.

34. I understand that, although anticipation cannot be established through a combination of references, additional references may be used to interpret the allegedly anticipating reference by, for example, indicating what the allegedly anticipating reference would have meant to one of ordinary skill in the art. However, for the claim to be anticipated, I understand that these other references must make clear that the missing descriptive matter in the patent claim is necessarily or implicitly present in the allegedly anticipating reference, and that it would be so recognized by one of ordinary skill in the art.

35. It is also my understanding that a claim is invalid if the claimed invention was known or used by others in the United States, or was in public use or on-sale before the critical date.

36. Consistent with what I noted above regarding the burden of proof, I have written this report with the understanding that anticipation must be shown by clear and convincing evidence.

37. A single prior art reference may anticipate without disclosing a feature of the claimed invention if such feature is necessarily present, or inherent, in that reference.

38. Under the principles of inherency, if the prior art necessarily functions in accordance with or includes the claimed elements, it anticipates. However, the prior art reference must necessarily include the non-disclosed element. Mere probabilistic inherency, or the

presence of an unrecognized de minimis quantity of a claimed substance in the prior art, cannot anticipate a later patent or patent application.

39. A prior art reference alleged to be anticipatory must also enable one of ordinary skill in the art to make the claimed invention without undue experimentation. There is a rebuttable presumption that prior art patents are enabled.

40. In my opinions below, when I say that a person of ordinary skill would understand, readily understand, or recognize that an element or aspect of a claim is disclosed by a reference, I mean that the element or aspect of the claim is disclosed explicitly to a person of ordinary skill in the art.

E. Obviousness Under 35 U.S.C. § 103

41. I further understand that a claimed invention is not patentable under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which the subject matter pertains.

42. I understand that a claim can be found invalid as obvious if the design incentives or market forces provided a reason to make an adaptation, and the invention resulted from the application of the prior knowledge in a predictable manner. I understand that a claim can be found invalid as obvious if the claim would have been obvious because the substitution of one known element for another would have yielded predictable results to one of ordinary skill in the art at the time of the invention. I understand that a claim can be found invalid as obvious if the claim would have been obvious because the technique for improving a particular class of devices was part of the ordinary capabilities of a person of ordinary skill in the art. I understand that a claim can be found invalid as obvious if the claim would have been obvious because a particular known technique was recognized as part of the ordinary capabilities of one skilled in the art. I

understand that a claim can be obvious in light of a single reference, without the need to combine references, if the elements of the claim that are not found in the reference can be supplied by the common sense of one of skill in the art.

43. In evaluating whether a claim would have been obvious, I have also considered the following factors:

- Whether the Plaintiff has identified a reason that would have prompted a person of ordinary skill in the art to combine the requirements or concepts from the prior art in the same way as in the claimed invention;
- Whether the claimed invention applies a known technique that had been used to improve a similar device or method in a similar way; and
- Whether the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art.

44. I understand that it is important to be careful not to determine obviousness using hindsight because many true inventions can seem obvious after the fact. Obviousness is determined from the position of a person of ordinary skill in the art at the time the claimed invention was made, and it is improper to consider what is known today or what is learned from the teaching of the patent. It is improper to use the ’988 and ’354 Patents as a road map for selecting and combining prior art.

45. The ultimate conclusion of whether a claim is obvious should be based on a determination of the following factual issues:

- The level of ordinary skill in the art that someone would have had at the time the claimed invention was made;
- The scope and content of the prior art;
- The differences, if any, that existed between the claimed invention and the prior art; and
- Secondary considerations or objective evidence of non-obviousness.

46. Secondary considerations or objective evidence of non-obviousness include the following:

- Commercial success of a product due to the merits of the claimed invention;
- A long-felt, but unsolved, need for the solution provided by the claimed invention;
- Unsuccessful attempts by others to find the solution provided by the claimed invention;
- Copying of the claimed invention by others;
- Unexpected and superior results from the claimed invention;
- Acceptance by others of the claimed invention as shown by praise from others in the field of the invention or from the licensing of the claimed invention; and
- Disclosures in the prior art that criticize, discredit, or otherwise discourage the claimed invention and would therefore tend to show that the invention was not obvious.

47. I have written this report with the understanding that obviousness must be shown by clear and convincing evidence.

F. <u>Enablement and Written Description Under 35 U.S.C. § 112, ¶ 1</u>

48. I understand that a patent must contain an enabling disclosure. The specification must contain a written description of the invention, and of the manner and process of making and using it so as to enable a person skilled in the art to make and use the invention. Because patents are presumed valid, lack of enablement must be proven by clear and convincing evidence.

49. Enablement is not precluded where a reasonable amount of routine experimentation is required to practice a claimed invention, however, such experimentation must not be undue. Whether a disclosure requires undue experimentation is not a single, simple factual determination, but rather is a conclusion reached by weighing many factual considerations.

50. In determining whether a disclosure requires undue experimentation, I understand that the relevant considerations can include:

- the quantity of experimentation necessary;
- the amount of direction or guidance presented;
- the presence or absence of working examples;
- the nature of the invention;
- the state of the prior art;
- the relative skill of those in the art;
- the predictability of the art; and

- the breadth of the claims.

51. Not every one of these factors need to be considered.

52. While the existence of a working example of the invention in the specification may be considered as one of many factors of sufficient enablement, working examples are, however, not required to satisfy the enablement requirement. Compliance with the enablement requirement does not turn on whether examples are disclosed in an application so long as the invention is otherwise disclosed in an enabling manner. Indeed, the importance of working examples may vary with the predictability of the art. Unlike in unpredictable arts, such as the biological, chemical, and pharmaceutical fields, the presence of a single embodiment may enable a broad claim when a more predictable art is in question, such as software design.

53. Elements and examples in the specification do not generally limit what is covered by the claims. A specification need not enable a perfected, commercially viable embodiment absent a claim element to that effect.

54. The enablement requirement is separate and distinct from the description requirement.

55. I understand that a patent must comply with a written description requirement by conveying with reasonable clarity to those skilled in the art that, as of the priority date sought, the inventor was in possession of the alleged invention, namely that the inventor had invented each feature that is included as a claim element. I have been informed that I am not to look for verbatim descriptions of the claim elements in the earlier-filed applications. Instead, I understand that the written description doctrine requires the disclosure of an application to adequately describe the invention so that a person of ordinary skill in the art can recognize that the patentee actually invented what is claimed in the patent at the time of filing. In other words, the question is whether

a person of ordinary skill in the art would have understood the inventors to have possessed the invention being claimed based on what is described in the application when it is filed. The disclosure may be either express disclosure (i.e., constituting text, figures, and other descriptive materials) or inherent. A disclosure is inherent if a person of ordinary skill in the art would have understood that the claimed subject matter is necessarily present in the material described in the application. I understand that the written description inquiry looks to the figures and the originally-filed claims in addition to the descriptive text of the application.

56. I also understand that the written description inquiry is not an inquiry into what would have been obvious over what is actually disclosed in the application. The question is not what a person of ordinary skill in the art could have made based on the teachings of the application. Instead, the inquiry focuses on what was described and how a person of ordinary skill in the art would have understood the disclosure.

VII. LEVEL OF SKILL IN THE ART

57. I am informed and understand that the claims of a patent are judged from the perspective of a hypothetical construct involving a "person of ordinary skill in the art." The "art" is the field of technology to which the patent is related. I understand that the purpose of using the viewpoint of a person of ordinary skill in the art is for objectivity. I understand that a person of ordinary skill in the art is presumed to know and be familiar with all of the relevant art in the field at the time of invention.

58. I was also asked to provide an opinion regarding the skill level of a person of ordinary skill in the art of the Family 10 Patents. I considered several factors, including the types of problems encountered in the art, the solutions to those problems, the pace of innovation in the field, the sophistication of the technology, my experience as a person who worked in the art prior to the Family 10 Patents' priority date, and the education level of active workers in the field.

59. At the time of the alleged invention, a person having ordinary skill in the art would have would have had a bachelor's degree in electrical or computer engineering and 5 years of experience in telecommunications or a related field, a Master's degree in electrical engineering and 2-3 years of experience in telecommunications or a related field, or a Ph.D. in electrical engineering with 1-2 years of experience in telecommunications or a related field.

60. I understand that TQ Delta proposes that a person of ordinary skill in the art "would have had a bachelor's degree in electrical engineering with 2-3 years of experience in DSL communication systems." Dkt. No. 124-12 at ¶20.

61. The Defendants' proposed level of ordinary skill in the art is the more appropriate level because it more accurately reflects the educational level of workers in the field. I believe that at least five years of experience in this field, without a master's degree, more accurately reflects the level work experience that workers in the field would have typically had that would be tasked to solve the problem presented by the '988 and '354 Patents. However, it is not uncommon for workers in the field of telecommunications or a related field to have a variety of technical degrees. Additional education might substitute for some of the experience, and substantial experience might substitute for some of the educational background.

62. Nevertheless, I was a person of ordinary skill in the art as of April 18, 2000, under either proposed definition. And my opinions express below are accurate and applicable under either level of ordinary skill in the art.

VIII. BACKGROUND OF THE TECHNOLOGY

A. Relevant Terminology

63. I am not intending to modify the Court's constructions in any way in this section but am simply providing basic definitions for the relevant terms used in the Family 10 Patents and the prior art documents referenced in this report.

1. <u>Digital Subscriber Line (DSL) Systems and Standards</u>

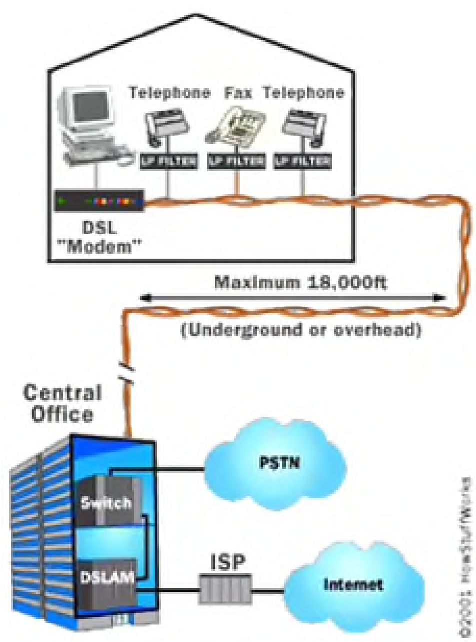
a. <u>DSL</u>

64. DSL (Digital Subscriber Line) is a technology for bringing high-bandwidth information to homes and small businesses over ordinary copper telephone lines. xDSL refers to different variations of DSL, such as ADSL, HDSL, and RADSL. However, DSL connections are greatly affected by the distance the signals are carried over the twisted wires and the size of the copper wire. Assuming the home or small business is close enough to a telephone company central office that offers DSL service, it may be able to receive data at rates up to 6.1 megabits (millions of bits) per second (of a theoretical 8.448 megabits per second), enabling continuous transmission of motion video, audio, and even 3-D effects. More typically, individual connections will provide from 1.544 Mbps to 512 Kbps downstream and about 128 Kbps upstream. A DSL line can carry both data and voice signals and the data part of the line is continuously connected. DSL installations began in 1998 and continued at a greatly increased pace through the next decade in many communities in the U.S. and elsewhere. *See e.g.*, NOK00808435 at NOK00808435. DSL, however, was conceived much earlier. The American National Standards Institute (ANSI) started the T1E1.4 Study Committee in the late 1980s, and in August of 1995, the Committee published T1.413-1995, "Network and Customer Installation Interfaces – Asymmetric Digital Subscriber Line (ADSL) Metallic Interface." *See* NOK00079270- NOK00079455. Subsequently, the Committee published a second version of the standard in 1998. *See* NOK00075245- NOK00075508.

65. As shown in the diagram below, traditional phone service (sometimes called POTS) for "plain old telephone service" connects your home or small business to a telephone company office over copper wires that are wound around each other and called twisted pair. Traditional phone service was created for the exchange of voice information with other phone

users using an analog signal. An input device, such as a phone set, takes an acoustic signal (which is a natural analog signal) and converts it into an electrical equivalent in terms of volume (signal amplitude) and pitch (frequency of wave change). Since the telephone company's signaling is already set up for this analog wave transmission, it's easier for it to use that as the way to get information back and forth between your telephone and the telephone company. That's why your computer must have a modem - so that it can demodulate the analog signal and turn its values into the string of 0 and 1 values that is called digital information. Note that the maximum length of the twisted pair of wires is 18,000 feet. NOK00808435 at NOK00808435.

66. These signals are communicated between the DSL modem located at the home or small business and a network device that is typically located at the telephone company switching office called a DSL Access Multiplexer (DSLAM). As also shown by the diagram below, the DSLAM separates the signals used for voice calls and the high-speed data packets. The voice calls are directed to the PSTN, and the data packets are typically directed to the Internet via an Internet Service Provider (ISP).



NOK00808450 at NOK00808456.

b. <u>ADSL</u>

67. The variation called ADSL (Asymmetric Digital Subscriber Line) is called "asymmetric" because most of its two-way or duplex bandwidth is devoted to the downstream direction, sending data to the user. Only a small portion of bandwidth is available for upstream or user interaction messages. However, most Internet and especially graphics- or multi-media intensive Web data need lots of downstream bandwidth, but user requests and responses are small and require little upstream bandwidth. *See e.g.,* NOK00808435 at NOK00808435. ADSL was defined before the alleged priority date of the Family 10 Patents[1] and uses the Discrete Multi-tone (DMT) multi-channel transmission technique as discussed in more detail below.

c. <u>VDSL</u>

68. VDSL (Very high data rate/speed DSL) supports much higher data rates over relatively shorter distances than ADSL. Like its predecessor ADSL, VDSL also uses the Discrete Multi-tone (DMT) multi-channel transmission technique as discussed in more detail below.

2. <u>Carrier(s)</u>

69. The terms carrier, subcarrier, subchannel, tone and bin are used interchangeably in the Family 10 Patents and the prior art. A person of ordinary skill in the art would have understood the term "carrier" to also mean subcarrier, subchannel, tone and bin as used in the prior art.

70. For example, the common specification of the Family 10 Patents uses carriers, subchannels and bins interchangeably with at least the following phrases: "a plurality of **carriers**[2]" ('354 Patent at Abstract); "Multicarrier modulation divides the transmission frequency

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[1] *See* ITU T-REC-G.992.1- 1999.07 for ADSL Transceivers.
[2] All emphasis has been added unless otherwise noted.

band into multiple **subchannels**, i.e., **carriers** or **bins**, with each **carrier** individually modulating a bit or a collection of bits. A transmitter modulates an input data stream containing information bits with one or more **carriers**, i.e., **bins** or **subchannels**, and transmits the modulated information" (*id.* at 1:33-39); "the margin is set to be different on at least two **subchannels** in a discrete multitone modulation system" (*id.* at 4:14-16); "higher frequency **subchannels**" and "smaller, set of **subchannels**" (*id.* at 2:66-3:2); "Individually, the **carriers** form discrete, non-overlapping communication **subchannels** which are of a limited bandwidth. Collectively, the **carriers** form what is effectively a broadband communications channel" (*id.* at 3:8-13); and "However, setting the margin equally for all **subchannels** …" (*id.* at 3:54-59). Therefore, all of these terms can be mapped to at least the "carriers" required in the Asserted Claims.

71. Kapoor similarly interchanges the terms "subchannels," "carrier tone subchannels," "bins," and "carriers" to also mean the same as "carriers" in the asserted claims. For instance, Kapoor is directed to "an apparatus and method for allocating bits among **carrier tone subchannels (bins)** in a discrete multi-tone modulation (DMT) communication system." Kapoor at 1:7-10. Kapoor uses the term "subchannels" to also mean "bins." *Id.* at 1:7-10. The specification and claims of Kapoor describe bit allocation in relation to both "subchannels" and "carrier tones." *Id.* at 8:49-64, 1:26-44. Therefore, all of these terms can be mapped to at least the "carriers" required in the Asserted Claims.

72. Cai uses the term "subchannel(s)" in its disclosure. *See e.g.,* Cai at Abstract. One of ordinary skill in the art would have understood that subchannel(s) means the same as carriers(s), just as the common specification of the Family 10 Patents interchangeably uses subchannel(s) and carrier(s) in the same context.

3. Multicarrier Transceiver

73. A Multicarrier Transceiver in the context of the Family 10 Patents is a DMT capable transmitter and receiver that share at least some common circuitry.

4. Multicarrier Modulation

74. As stated in the prior art, the "fundamental goal of all 'multicarrier' modulation techniques is to partition a data transmission channel with ISI into a set of orthogonal, memoryless subchannels, each with its own "carrier." Chow at 16-17. Chow also recognizes that a number of different channel partitioning techniques have been proposed in the literature and are thus a part of the prior art scheme at the time. These partitioning techniques include: using channel eigenvectors, or eigenfunctions, in Vector Coding (VC) and Structured Channel Signaling (SCS); using Inverse Discrete Fourier Transform (IDFT) and Discrete Fourier Transform (DFT) vectors in DMT modulation; and using M-band wavelet transforms in Discrete Wavelet Multitone (DWMT) modulation. *Id.* at 17. Choosing which optimal channel partitioning scheme to use depends on the particular representation of the channel and the noise. *Id.* Figure 1.1 from Chow "illustrates a clock diagram of a typical digital communication system" and includes multicarrier modulation. *Id.* at 2.

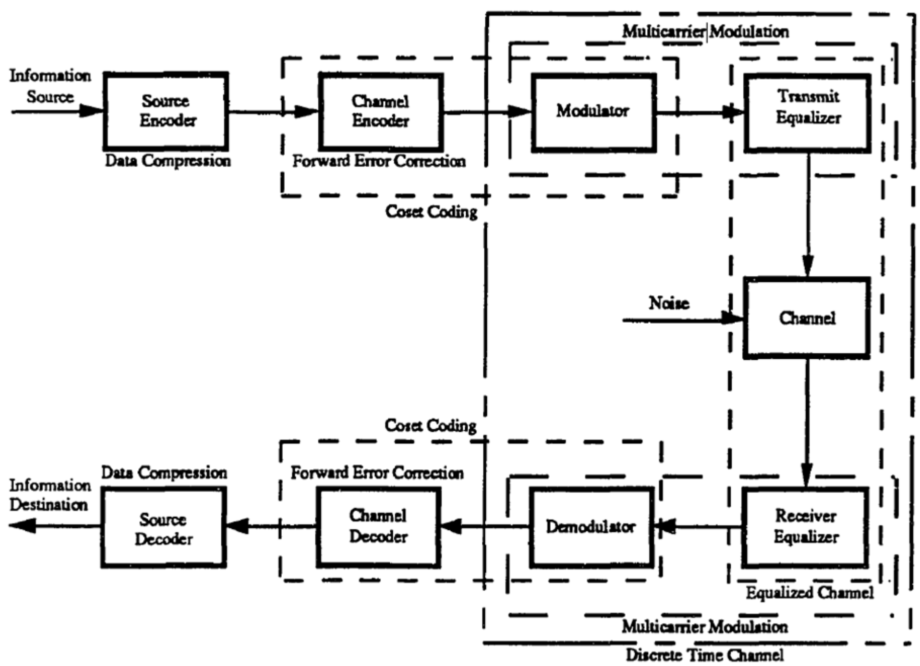


Figure 1.1: Digital Communication System Model

Id. at Fig. 1.1.

75. The source encoder and decoder pair "seeks to increase overall data rate by intelligently removing redundancy, through data compression, from the "raw" or the original digital data source" which consists of different forms of data, including bits as mentioned in the Family 10 Patents. *Id.* at 3.

76. The channel encoder and decoder pair "aims to increase the reliability of transmission by efficiently inserting controlled redundancy, through error control coding, back into the transmitter data stream in order to aid the recovery of data and the presence of noise." *Id.* at 3.

77. As Chow states, "discrete time symbols cannot be transmitted directly through a physical channel," thus requiring another method in order to transmit data. Chow at 3. Thus, "modulation is necessary to convey a discrete time signal into a continuous time signal, and

demodulation performs the inverse operation at the receiver to translate the received continuous time signal back to digital form." *Id.*

a. Discrete Multitone Modulation (DMT)

78. DMT has been well known since at least 1993 when a detailed article was published by Chow[3], et al. Peeters at 3:50-55. DMT (Discrete Multi-Tone) is a method of converting digital data into tones or frequencies that can be carried over telephone wire. Chow states that "in practice, [when choosing which channel partitioning method to use] DMT modulation is the preferred methodology because of its advantage in computation complexity" and it "enjoys a number of 'canonical' properties." Chow at 17. Chow also recognizes that from a complexity/performance tradeoff standpoint, the DMT appears to be more suitable for applications where discontinuities within the optimal transmission band are common." *Id.* at 31. Chow defines the basic structure of a DMT modulation in Figure 2.4:

[3] Chow et al., *A Multicarrier E1-HDSL Transceiver System with Coded Modulation,* Journal of European Transactions on Telecommunications and Related Technologies (ETT), p. 257-66 (May/June 1993).

The general structure of a DMT system is illustrated in Figure 2.4, where $\{X_0, X_1, \ldots, X_{N-1}\}$ are the original, complex, input data symbols, $\{x_k\}$ is the modulated data sequence (before cyclic prefix), $\{y_k\}$ is the received sequence (after the removal of cyclic prefix), and $\{\tilde{X}_0, \tilde{X}_1, \ldots, \tilde{X}_{N-1}\}$ are the decoded, complex data symbols. The $\mathbf{p}_i$'s and $\mathbf{p}_i^*$'s in Figure 2.4 are known as the modulating and the demodulating

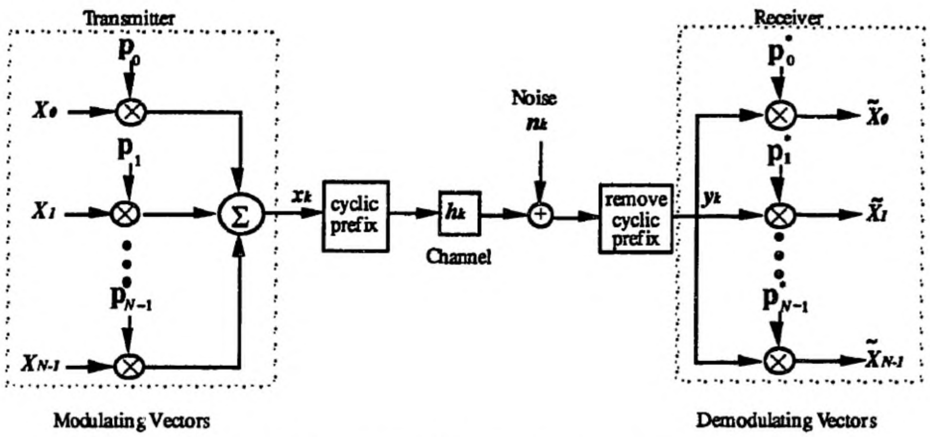


Figure 2.4: Basic Structure of Discrete Multitone Modulation

vectors for discrete-time systems, or basis functions for continuous-time systems, and in general, they are chosen to be orthonormal. Therefore, for a discrete-time

Id. at Fig. 2.4.

79. But, "multicarrier modulation techniques for data communication are not new and have been known and used for the past 50 years." Kapoor at 1:46-48.

80. DMT is called "Multi-Tone" because it splits the available frequencies into a defined number of smaller sub-channels or tones, and it is considered to be "discrete" from the mathematical term meaning these subchannels tones are distinct or separate. Therefore, each sub-channel or tone will only have one modulated symbol at any point in time. '354 Patent at 1:33-2:44; Cai at 1:18-62; Peeters at 3:47-58, 5:50-6:15; Kapoor at 1:31-2:46; NOK00808435 at NOK00808435.

5. <u>DMT Symbol or Multicarrier Symbol and Frame Rate</u>

81. A DMT Symbol is also called a multicarrier symbol and, at least for ADSL and VDSL, it refers to a specific time period when the QAM symbol for each subcarrier is transmitted.

For example, ADSL supports a maximum of 254[4] subcarriers in the downstream direction (from the PSTN network to a home or small business) for each specific time period (symbol period) and all of these subchannels transmitted together would be considered to be a "DMT Symbol" or a "multicarrier symbol." ADSL transmits at a DMT symbol rate of 4,000 times per second or 4 KHz. This "DMT symbol rate" or "multicarrier symbol rate" is also referred to as the "DMT frame rate" or sometimes just the "frame rate."

82. Thus, to calculate the theoretical maximum bit speed for a specific type of DSL line, the DMT symbol rate (DMT frame rate) is multiplied by the maximum number of bits carried by each subchannel and the maximum number of subchannels that can be used. For an ADSL line with 254 subcarriers, a DMT frame rate of 4,000 times/sec and a maximum of 15 data bits modulated by each subcarrier symbol, the theoretical downstream bit rate is 254 * 4,000 * 15 = 15,240,000 or 15.24 Mbps. In reality, there are many factors that significantly reduce this maximum rate for operational ADSL links.

6. Modulation Method and Number of Bits Carried

83. Modulation is the process of converting one or more digital bits into an analog waveform. There are many different types of modulation methods. ADSL uses a modulation method called Quadrature Amplitude Modulation (QAM). QAM supports different constellations that can represent up to a maximum of 15 bits for ADSL. The QAM constellation increases in complexity as the number of bits it represents increases. The resulting analog waveform generated from converting the digital bits is called a symbol. The better the SNR that a subcarrier has, the more complex QAM symbol can be used, which translates into carrying more data bits. For example, a QAM symbol carrying 15 bits of data must have a constellation that conveys

[4] Subcarriers 64 and 256 are not used to transfer user data.

32,768 (32K binary) different points to represent all the different combinations that 15 binary bits can represent. Inversely, as the SNR of a subcarrier decreases, the number of bits carried by its QAM symbol constellation decreases proportionally because the receiver will not be able to discern constellations with a high number of points on a channel with more noise.

7. Demodulating Bits from a Carrier or Subcarrier

84. When a DMT receiver receives a DMT symbol, it needs to separate each subcarrier, which contains a single QAM symbol at a point in time. The receiver then does the reverse process performed by the transmitter by converting each analog symbol into a group of bits. This process is call demodulation.

8. Bit-Loading Allocation in DMT

85. Bit-loading allocation is simply the "distribution of data information among the channels." Kapoor at 1:43-45. To make efficient use of the available bandwidth, DMT systems use a technique called bit-loading to adjust the size of the signal constellation on each tone according to the SNR on the corresponding tone. In other words, if the channel/tone has a good SNR, a more complex signal constellation is used to transfer more data bits for each symbol. If a channel has a poor SNR, the simplest signal constellation is used, which carries the fewest data bits per symbol. For VDSL, the type of signal constellations—modulation methods, used are: 1) quadrature amplitude modulation (QAM), 2) phase shift keying (PSK), 3) frequency shift keying (FSK), and 4) minimum shift keying (MSK).

86. Chow discusses QAM in correspondence to an infinite-length, single-carrier modulation and equalization. Chow at 10. QAM is implemented with a minimum-mean-squared-error decision Feedback equalizer (MMSE-DFE) receiver. *Id.* Chow further discusses the similarities of MMSE-DFE and DMT and how it relates to their research in multicarrier techniques: "While fundamentally very different, in the asymptotic case, the DMT and the

MMSE-DFE systems can be shown to have virtually the same performance [11], and this performance connection is re-derived in Section 2.5. We further observe that these two systems will also use virtually the same flat energy transmission bandwidth to achieve this asymptotic performance level. Based on this observation, we propose the use of multicarrier techniques to obtain the symbol rate and the carrier frequency, thus the transmission bandwidth, of a single-carrier system as well." *Id.* at 10.

87. Thus, the "plurality of bits" on the "plurality of carriers" in the Family 10 asserted claims are referring to the number of user data bits that are modulated by each QAM symbol on each subcarrier. For example, for ADSL, there is a maximum of 15 bits modulated per subcarrier as described above. In other words, each modulated symbol on each subcarrier represents only a specific number of bits for in any point in time.

9. Broadband Communication Channel, Communications Link

88. The common specification of the Family 10 Patents describes the Broadband Communications Channel as "[i]ndividually, the carriers form discrete, non-overlapping communication subchannels which are of a limited bandwidth. Collectively, the carriers form what is effectively a **broadband communications channel**." '354 Patent at 3:8-12. The common specification of the Family 10 Patents also refers to it as the "Communications Link." *Id.* at 6:23-26, 8:2-6.

10. Decibel (dB) Measurement

89. The '988 and '354 Patents describe how typical ADSL systems use a 6 dB margin on all subchannels carrying bits. '354 Patent at 2:41-45. The ability to set a common margin was also well known prior to the priority date of the Family 10 Patents. As one example, Cai describes that it is "typical practice to subtract a common margin, typically 6 dB, from the measured signal-to-noise ratio of each channel to obtain a transmission signal-to-noise ratio at which to achieve a

bit error rate of approximately 10^{-7}." Cai at 1:44-48. Cai exemplifies this with the same margin shown on each channel in Fig. 1:

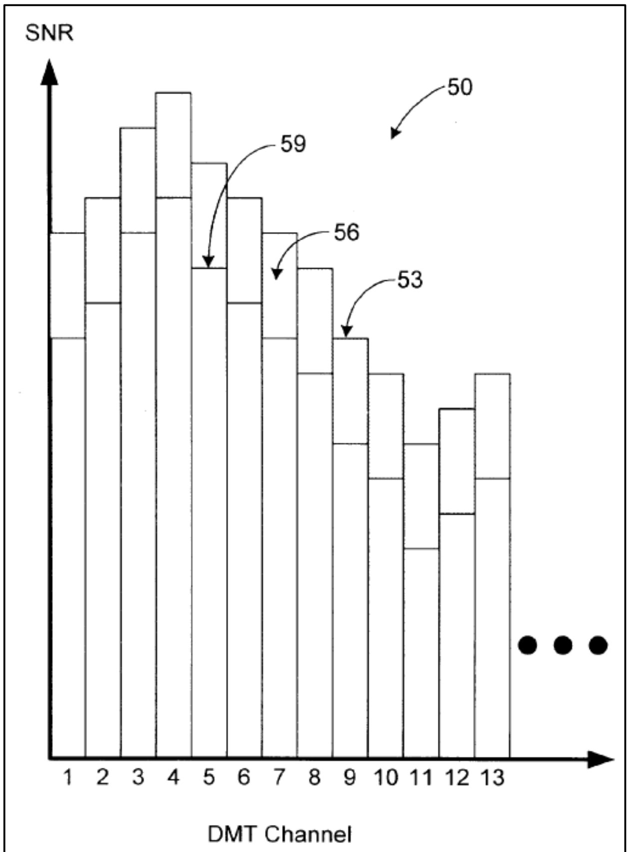


Fig. 1
(Prior Art)

Cai at Fig. 1.

11. <u>Signal-to-Noise Ratio (SNR)</u>

90. Signal-to-noise ratio (SNR) is a well-known parameter used in a variety of communication techniques, including DSL. The signal to noise ratio (SNR) is the ratio of signal power to the noise power, which is commonly expressed in decibels (dB). The common specification of the Family 10 Patents describes that the DMT transceivers "modulate the number of bits on each subchannel . . . depending on the Signal to Noise Ratio (SNR) of that subchannel

and the Bit Error Rate (BER) requirement of the link." '354 Patent at 1:57-60. As described in the common specification of the Family 10 Patents, and well known prior to April 18, 2000, the signal to noise ratio is measured at the carrier level. The measured SNR of each carrier (i.e., the actual SNR margin) is used to subtract the SNR margin for each respective carrier to determine the SNR threshold of each carrier. Cai at 2:64-67. A person of ordinary skill in the art would have understood that only one SNR margin would be applied to each carrier/subchannel at any point in time.

91. Chow also describes an SNR Gap as "a particularly convenient, single-parameter characterization of the digital communication channel . . . which can be applied to the analysis of a number of digital communication systems." Chow at 9. Conceptually, "SNR gap is a measure of how a particular communication system is performing relative to the channel capacity." *Id.* at 13.

12. <u>Signal-to-Noise Ratio Margin (SNR Margin)</u>

92. Signal-to-noise ratio margin (SNR Margin) is a well-known parameter used in a variety of communication techniques, including DSL. The common specification of the Family 10 Patents describes the SNR Margin as "an extra SNR per subchannel, in addition to what is required to maintain the specified BER requirement." '354 Patent at 2:4-9. The common specification of the Family 10 Patents describes that SNR Margins were well known prior to April 18 2000. '354 Patent at 2:41-45.

93. I also understand that the parties construed SNR Margin, used in the Asserted Claims language, to incorporate this definition from the specification. *See supra* § X.

94. The prior art additionally defines it as an "SNR Gap". Kapoor at 2:21-23 ("Transmission channels are typically characterized by the channel's margin, signal-to-noise ratio gap (hereinafter SNR gap), and capacity. All are related concepts."); *see also* Chow at 9-13. For

instance, Kapoor describes the SNR Gap as “the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for abarticular type of modulation scheme with particular SNR gap.” *Id*. at 2:23-27. Kapoor also describes that the SNR gap “is a function of a chosen probability of transmission error and the modulation and coding techniques.” *Id.* at 2:27-29.

13. <u>Bit Error Rate (BER)</u>

95. The Bit Error Rate (BER) is the percentage of bits that have errors relative to the total number of bits received in transmission, generally expressed as a ten to a negative power (i.e., $1x10^{-7}$). The common specification of the Family 10 Patents describes that BER is generally set in advance, for example, by the manufacturer. ’354 Patent at 7:51-52.

IX. <u>THE FAMILY 10 PATENTS</u>

96. The Family 10 Patents share a common specification, and both claim priority to the same Provisional Application No. 60/197,727 through a series of continuations. Thus, my description of the ’354 Patent is equally applicable to the ’988 Patent.

97. The ’354 Patent to Marcos C. Tzannes titled “Systems and methods for a multicarrier modulation system with a variable margin” discusses systems and methods to increase the data rate and impairment immunity of data transmitted via a multicarrier modem by assigning different margins to different carriers. ’’354 Patent at Abstract. The invention relates to communications technologies, in particular, “multicarrier modulation systems having multiple margins.” ’354 Patent at 1:28-30.

98. Discrete Multitone Modulation (DMT) is a transmission method in telecommunications which divides the transmission frequency band into multiple sub-channels, known as carriers or bins, where each carrier individually modulates a bit or collection or bits. *Id.* at 1:32-43. “A transmitter modulates an input data stream containing information bits with

one or more carriers . . . and transmits the modulated information" where a receiver then demodulates the information to recover the output data stream. *Id.* at 1:37-43.

99. Typically, transceivers or multicarrier modems (hereinafter referred to as "modems") have an upstream modem at a central office (called a ADSL transceiver unit, central office or ATU-C) and a downstream modem located at a business or customer location (called a "ADSL transceiver unit, remote or ATU-R). *Id.* at 2:49-3:2. Usually, the data transmitted from ATU-C to ATU-R is transmitted on a first set of high frequency subchannels. *Id.* Data transmitted from ATU-R to ATU-C is performed on a second set of lower-frequency subchannels. *Id.* The data transmitted on these channels is done so by using a "multiplicity of discrete frequency carriers" which individually form "discrete, non-overlapping communications sub-channels which are of limited bandwidth." *Id.* at 3:3-13.

100. Figure 1 below is a functional block diagram illustrating an exemplary modem according to the '354 Patent.

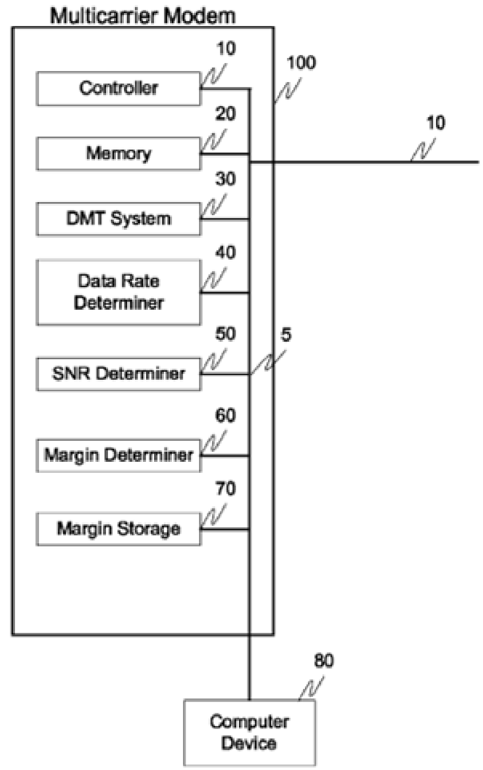


Fig. 1

’354 Patent at Fig. 1.

101. DSL systems experience disturbances from other devices on adjacent phone lines. *See id.* at 3:14-26 (“DSL systems may experience disturbances from impulse noise, crosstalk, temperature changes, or the like…. [and] the length of the phone line is a type of impairment that varies from one ADSL subscriber to another”). To minimize disturbances, the ’354 Patent claims systems and methods of allowing “the margin in a discrete multitone modulation system to vary depending on a type of impairment” the DSL system may experience. *Id.* at 3:27-29. Specifically, the ’354 Patent describes a communications system having a plurality of margins, where the margin is set to be different on at least two different subchannels in a DMT system and “subchannels which are expected to incur greater variations in impairment levels are set to have

a higher margin, whereas subchannels which are expected to incur lower variations in impairment levels are set to have lower margins." *Id.* at 4:16-20.

102. Figure 2 of the patent is a flowchart outlining a method for assigning margins:

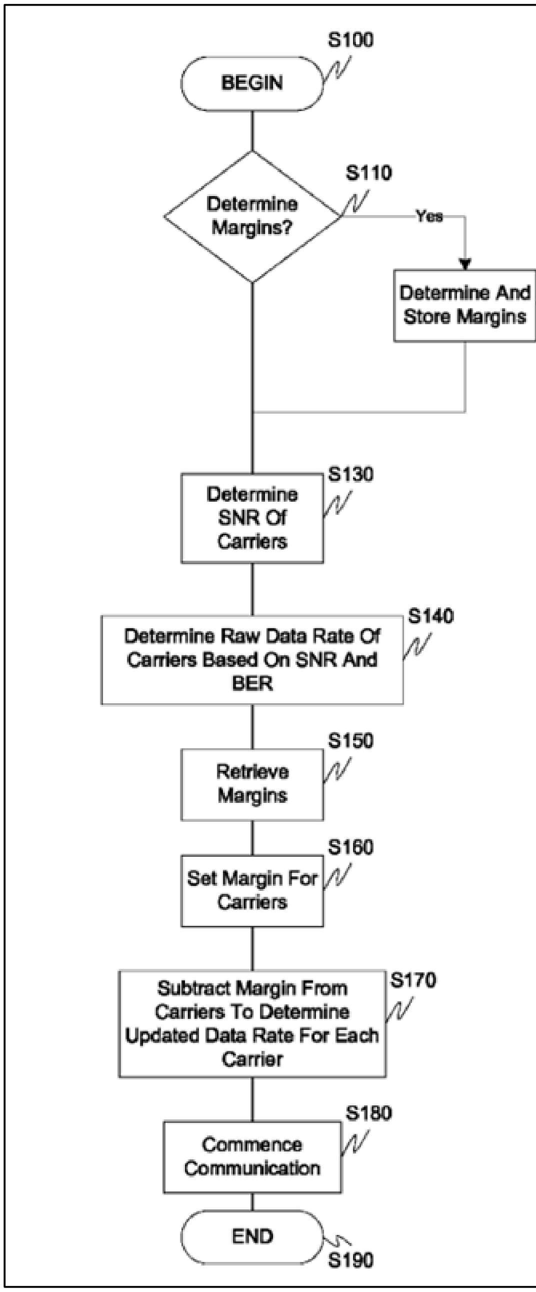


Fig. 2

'354 Patent at Fig. 2.

A. <u>Asserted Claims</u>

103. The asserted claim of the '354 Patent is claim 10. Claim 10 recites:

[Pre.] A multicarrier communications transceiver operable to:

[a.] receive a multicarrier symbol comprising a first plurality of carriers

[b.] and a second plurality of carriers;

[c.] receive a first plurality of bits on the first plurality of carriers using a first SNR margin;

[d.] receive a second plurality of bits on the second plurality of carriers using a second SNR margin;

[e.] wherein the first plurality of carriers is different than the second plurality of carriers,

[f.] wherein the first SNR margin is different than the second SNR margin, and

[g.] wherein the first SNR margin provides more robust reception than the second SNR margin.

104. The asserted claim of the ’988 Patent is claim 16. Claim 16 recites:

[Pre.] An apparatus comprising: a multicarrier communications transceiver

[a.] operable to demodulate for reception a first plurality of bits from a first carrier

[b.] using a first Signal to Noise Ratio (SNR) margin

[c.] and to demodulate for reception a second plurality of bits from a second carrier

[d.] using a second SNR margin,

[e.] and to demodulate for reception a third plurality of bits from the first carrier

[f.] using a third SNR margin,

[g.] wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,

[h.] wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier,

[i.] wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,

[j.] wherein the first SNR margin is different than the second SNR margin,

[k.] wherein the first SNR margin is different than the third SNR margin, and

[l.] wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another.

1. <u>File History</u>

a. ’354 Patent File History

105. The ’354 Patent issued from U.S. Application No. 14/591,612 (“the ’612 application”) titled “Systems and Methods for a Multicarrier Modulation System with a Variable Margin,” filed on January 7, 2015. The ’612 application claims the benefit of U.S. provisional Application No. 60/197,727, filed on April 18, 2000.

106. In a Preliminary Amendment dated January 7, 2015, claims 2-45 were cancelled and the applicant requested an examination on the merits on the basis of a single claim, claim 1, which claimed: “A multicarrier modulation communication system comprising: a plurality of subchannels; and a plurality of margins.” TQD_TX-00012883 at TQD_TX-00013016-19. Claim 1 was subsequently rejected by the examiner on the ground of nonstatutory obviousness-type double patenting because the claim was not patently distinct from claim 1 of U.S. Patent No. 8,347,226, and as anticipated under 35 U.S.C. § 102(e) in light of Kapoor. *Id.* at TQD_TX-00012984- 90. The Examiner specifically stated that Kapoor “discloses a multicarrier modulation communication system (FIG. 1 discloses a multicarrier modulation communication system; column 5 lines 22-26) comprising: a plurality of subchannels; and a plurality of margins (Kapoor et al. discloses a plurality of SNR margins for different subchannels; column 11 lines 50-55)”. *Id.* at TQD_TX-00012988; Kapoor at 5:22-26; 11:50-55.

107. U.S. Patent No. 6,516,027 to Kapoor et al. (“Kapoor”) and U.S. Patent. No. 6,205,410 to Cai (“Cai”) were included in the information disclosure statement by the applicant.

Id. at TQD_TX-00013087. In response to the non-final rejection dated February 9, 2015, the applicant filed an amendment on May 14, 2015, which cancelled the previous claim 1 and added new claims 46-57. *Id.* at TQD_TX-00012971-75.

108. These claims were eventually allowed in the Notice of Allowance dated July 29, 2015. *Id.* at TQD_TX-00012946-49. In the reasons for allowance, the Examiner noted that the prior art of record did not disclose "transmitting/receiving a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers" in claims 46, 49, 52, and 55 of the application. *Id*. at TQD_TX-00012947. The '354 patent issued October 6, 2015. *Id.* at TQD_TX-00012934. Several years after the Notice of Allowance, on September 26, 2018, the Applicant filed a certificate of correction to change the language of claim 10 of the '354 Patent. *Id.* at TQD_TX-00012927. The applicant requested the addition of words "transmission than the second SNR margin" to be added after "robust" in claim 10. *Id*. The amendment was approved October 30, 2018. *Id.* at TQD_TX-00012925-26. A second Request for Certificate of Correction was filed May 10, 2021 to replace the word "transmission" in claim 10 to "reception," which rendered the new claim language of claim 10 as: "robust reception than the second SNR margin." *Id.* at TQD_TX-00012885-86. The Certificate of Correction was granted on June 15, 2021. *Id.* at TQD_TX-00012883.

b. '988 Patent File History

109. The '988 Patent issued from U.S. Application No. 14/079,285 ("the '285 application"), titled "Systems and methods for a multicarrier modulation system with a variable margin" filed on November 13, 2013. The '285 application claims the benefit of U.S. provisional Application No. 60/197,727, filed on April 18, 2000. In a Preliminary Amendment dated November 13, 2013, claims 2-45 were cancelled and the applicant requested an examination on

the merits on the basis of a single claim, claim 1, which claimed: "A multicarrier modulation communication system comprising: a plurality of subchannels; and a plurality of margins." TQD_TX-00010134 at TQD_TX-00010305.

110. A second Preliminary Amendment was filed on December 23, 2013 to add claims 46-71. *Id.* at TQD_TX-00010287-92. On December 26, 2013, the Office issued a Non-Final Rejection. *Id.* at TQD_TX-00010271-76. Claim 1 was rejected by the examiner on the ground of nonstatutory obviousness-type double patenting because the claim was not patently distinct from claim 1 of U.S. Patent No. 8,347,226 and as anticipated under 35 U.S.C. § 102(e) in light of Kapoor. *Id.* at TQD_TX-00010273. The Examiner specifically stated that Kapoor "discloses a multicarrier modulation communication system (FIG. 1 discloses a multicarrier modulation communication system; column 5 lines 22-26) comprising: a plurality of subchannels; and a plurality of margins (Kapoor et al. discloses a plurality of SNR margins for different subchannels; column 11 lines 50-55)". *Id.* at TQD_TX-00010274; Kapoor at 5:22-26; 11:50-55.

111. Kapoor and Cai were included in the information disclosure statement by the applicant. *Id.* at TQD_TX-00010375. On December 27, 2013, the applicant amended claim 1 to add limitations and argued that Kapoor no longer anticipated claim 1 under 35 U.S.C. § 102(e) in light of the changes made. *Id.* at TQD_TX-00010256-63. For claim 1, the added limitations are as follows:

1. (Currently Amended) A multicarrier modulation communication system comprising:

a plurality of subchannels; and

a plurality of margins,

the multicarrier modulation communications system operable to:

configure a first Signal-to-Noise Ratio (SNR) margin of the plurality of margins for transmitting a first plurality of bits on a first plurality of carriers; and

configure a second Signal-to-Noise Ratio (SNR) margin of the plurality of margins for transmitting a second plurality of bits on a second plurality of carriers,

wherein the first plurality of carriers is different than the second plurality of carriers,

wherein the first SNR margin specifies a first value to account for an increase in noise associated with the first plurality of carriers,

wherein the second SNR margin specifies a second value to account for an increase in noise associated with the second plurality of carriers, and

wherein the first value for the increase in noise is different than the second value for the increase in noise.

Id.

112. The applicant also made several changes to claims 46-71. *Id.* at TQD_TX-00010257-61.

113. On March 11, 2014, the Office issued a Final Rejection in response to the applicant's arguments made in its December 27, 2013 Amendment Request. *Id.* at TQD_TX-00010234-51. In its Final Rejection, the Office rejected claims 46-48, 50, 53-60, and 63-70 on the ground of nonstatutory double patenting as being unpatentable over U.S. Patent No. 8,625,660 because it was not patentably distinct. *Id*. The Office rejected Claims 1, 46-52, 55, 57-62, 65 and 67-71 under pre-AIA 35 U.S.C. 103(a) as being unpatentable over McHale et al. U.S. Patent No. 6,278,728. *Id.*

114. After the Final Rejection, the applicant filed a Request for Continued Examination on August 13, 2014. *Id.* at TQD_TX-00010213-30. In its Request, applicant then cancelled claims 1-71 and put forth new claims 72-95. *Id.* at TQD_TX-00010221-29.

115. On September 16, 2014, the Office issued its Notice of Allowance. *Id.* at TQD_TX-00010190-93. In its decision, the Examiner stated that the claims were allowed over the prior art because the claim limitations "modulating for transmission, in said transceiver a third plurality of bits onto said first carrier using a third SNR margin" and "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier, wherein the first SNR margin is different than the second SNR margin wherein the first SNR margin is different than the third SNR margin" were not disclosed or anticipated by the prior art. *Id.* at TQD_TX-00010191.

116. Kapoor and Cai were included in the information disclosure statement by the applicant. *Id.* at TQD_TX-00010375. The '988 Patent was issued over Cai, but the examiner declined to further comment on Cai in their rationale. *Id.* at TQD_TX-00010192. The patent issued on December 30, 2014. TQD_TX-00010167.

X. CLAIM CONSTRUCTION

117. I have reviewed the Court's Claim Construction Memorandum and Order, issued on June 8, 2022. A summary of the terms for which the Court provided a construction is provided below:

Term or Phrase	Court's Construction
"operable to" '354 Patent, claim 10; 988 'claim 16	"configured to" (Dkt. No. 169) at 16.
"a multicarrier communications transceiver operable to: receive a multicarrier symbol comprising a first plurality of carriers" '354 Patent, claim 10	Plain meaning. Claim Construction Memorandum and Order (Dkt. No. 169) at 106.

Term or Phrase	Court's Construction
"receive a first plurality of bits on the first plurality of carriers using a first SNR margin; receive a second plurality of bits on the second plurality of carriers using a second SNR margin" '354 Patent, claim 10	Plain meaning. Claim Construction Memorandum and Order (Dkt. No. 169) at 110.
"wherein the first SNR margin provides more robust reception than the second SNR margin" '354 Patent, claim 10	"wherein the first SNR margin is greater than the second SNR margin." Claim Construction Memorandum and Order (Dkt. No. 169) at 113.
"signal to noise ratio (SNR) margin" and "SNR margin" '988 Patent, Claim 16; '354 Patent, Claim 10	"a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

118. In my analysis, I have applied the Court's constructions. I have interpreted the remaining claim terms as they would have been understood by a person having ordinary skill in the art on the priority date of the Family 10 Patents, considering the context of the claims themselves, the specification, the figures, the prior art, and the prosecution history. Consistent with these constructions and interpretations, I have considered the claims in light of the ordinary meaning of the claims based on the perspective of one of skill in the art and consistent with my experience in the field.

XI. INVALIDITY UNDER 35 U.S.C. § 112

A. Claim 10 of the '354 Patent Does Not Meet the Written Description and/or Enablement Requirements of 35 U.S.C. § 112, First Paragraph

1. Written Description Requirement

119. It is my understanding that under 35 U.S.C. § 112, the specification must contain a written description of the invention. I understand that in order to comply with the written

description requirement, a patent must allow one skilled in the art to visualize or recognize the identity of the subject matter purportedly claimed. I also understand that a broad claim does not satisfy the written description requirement when the entirety of the specification clearly indicates that the invention is of a much narrower scope.

120. Claim 10 requires a transceiver "operable to [] receive a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers", wherein "the first plurality of carriers is different than the second plurality of carriers." '354 Patent at 10:36-47.

121. Among other things, claim 10 also requires a transceiver to "receive a [first/second] plurality of bits on the [first/second] plurality of carriers using a [first/second] SNR margin." *Id.*

122. A person having ordinary skill in the art would not have concluded, based on the detail provided in the written description and drawings of the '354 Patent that the inventors had possession of the full scope of the claimed invention, as the claims have been construed, and as they are interpreted by TQ Delta.

123. A person of ordinary skill in the art would have understood that the SNR received on each subchannel and the desired BER for the broadband connection (link) are the two parameters used to allocate the number of data bits to be carried by each modulated symbol on each respective subchannel. These bits are allocated during the bit allocation process at the transmitter portion of the transceiver. This is consistent with the '354 Patent specification, which describes using SNR during the bit allocation process:

> Discrete multitone modulation transceivers ***modulate*** a number of bits on each subchannel, the number of bits depending on the ***Signal to Noise Ratio (SNR)*** of that sub channel and the Bit Error Rate (BER) requirement of a link. For example, if the required BER is $1x10^{-7}$, i.e., one bit in ten million is received in error on average, and the SNR of a particular subchannel is 21.5 dB, then that subchannel can modulate 4 bits, since 21.5 dB is the required ***SNR* to *transmit*** 4 QAM bits

> with a $1x10^{-7}$ BER. Other subchannels can have a different *SNR* and therefore may have a different number of bits allocated to them at the same BER. Additional information regarding bit loading can be found in copending U.S. application Ser. No. 09/510,773, incorporated herein by reference in its entirety.

Id. at 1:57-2:3 (emphasis added).[5]

124. The ’354 Patent specification describes the SNR Margin as an “additional parameter is used to determine the number of bits allocated to each subchannel” by “specify[ing] an extra SNR per subchannel, in addition to what is required to maintain the specified BER requirement.” *Id.* at 2:4-9. “As an example, a DMT system with a 6 dB margin would require a 21.5+6=27.5 dB SNR on a subchannel in order to transmit 4 bits on that subchannel with a $1x10^{-7}$ BER.” *Id.* at 2:9-12. The Court has also construed “SNR Margin” to mean “parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation.” Claim Construction Order, Dkt. No. 169 at 116.

125. The ’354 Patent specifically recognizes that “DMT transceivers use a margin to increase the system’s immunity to various types of time varying impairments.” *Id.* at 2:17-18. This immunity is implemented by “assigning” a SNR margin to one or more of the carriers. *Id.* at 3:27-33, 3:64-67, 4:10-11; 5:20-24, 9:22-24. A person of ordinary skill in the art would have understood, as described in the ’354 Patent specification, that the transmitter portion of the transceiver is used to assign the SNR margin to each subchannel, which is used on the [first/second] plurality of carriers for bit loading. *Id.* at 2:4-12 (since 21.5 dB is the required SNR to *transmit* 4 QAM bits with a $1x10^{-7}$ BER).

[5] U.S. application Ser. No. 09/510,773 is not publicly available.

126. This is further evidenced by FIG. 2, which "illustrates an exemplary method of assigning margins to carriers according to an exemplary embodiment of this invention":

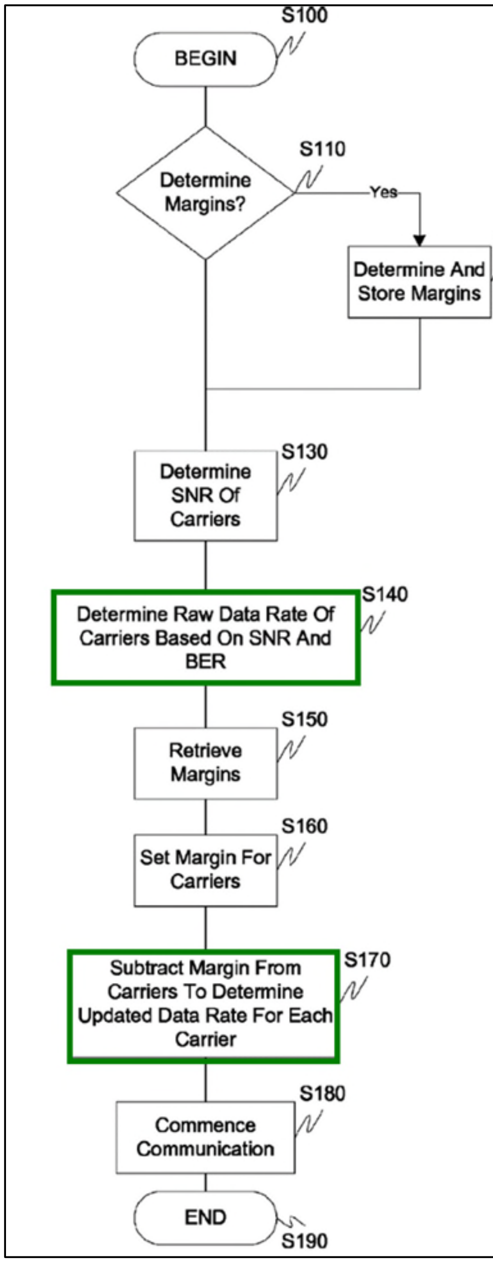


Fig. 2

'354 Patent at 8:7-9, Fig. 2.

127. The specification describes this method as follows:

> In particular, control begins in step S100 and continues to step S110. In step S110, a determination is made whether margins are to be determined. If margins

> are to be determined, control continues to step S120. Otherwise, control jumps to step S130.
>
> In step S120, the margins are determined and stored. Control then continues to step S130.
>
> In step S130 the signal to noise ratio of the carriers are determined. Next, in step S140, the raw data rate of the carriers is determined based on the signal to noise ratio and the bit error rate. Next, in step S150, the margins for the carriers are retrieved. Control then continues to step S160.
>
> In step S160, the margins for the carriers are set. Next, in step S170, the margins are subtracted from the carriers to determine an updated data rate for each carrier. Control then continues to step S180.
>
> In step S180, communications commence. Control then continues to step S190 where the control sequence ends.

Id. at 8:9-26.

128. In the exemplary method described above, the '354 Patent specification only describes the bit allocation process at the transmitter portion of the transceiver. Specifically for Fig. 2, in box S150, the transmitter retrieves the margins that have been previously stored in box S120. In box S160, the transmitter sets the margin for each carrier, and in box S170, the transmitter determines the updated data rate for each carrier. This data rate for each carrier is based on the number of bits that transmitter inserts into each symbol. Thus, the transmitter is determining and inserting the "plurality of bits" on each carrier based on this additional SNR margin information and not the receiver.

129. Additionally, the '354 Patent specification teaches that these SNR margins can be "downloaded" or "entered criteria" and can be based on "an increased bit error rate," "changes in the signal to noise ratio" "geographic information, seasonal information, line length information, or the like." *Id.* at 7:4-42. A person of ordinary skill would have understood that these downloaded or entered parameters would only need to be considered by the transmitter (not the

receiver) in order for it to execute boxes S160 and S170 before transmitting (commence communication) in box S180, as described above.

130. By contrast, the receiver part of the transceiver is the device performing the receiving function in claim 10 of the '354 Patent, is used to "receive data." *Id.* at 2:60-64; 1:39-41. The '354 Patent does disclose that the receiver provides SNR feedback to the transmitter for each channel in box S130 and the SNR needs to be measured by the receiver. However, this is only the first parameter described above and is not the third parameter called the SNR margin or margin. Because the transmitter, and not the receiver, applies the third parameter (boxes S160 and S170), only the transmitter knows what ultimate plurality of bits (i.e., bit allocation) it used for each subchannel. Thus, one of ordinary skill in the art would not understand with reasonable certainty as to how the receiver would determine or use a first or second SNR as required by claim 10. For these reasons, claim 10 lacks written description.

2. Enablement Requirement

131. I understand that a patent must contain an enabling disclosure. The specification must contain a written description of the invention, and the manner and process of making or using it so as to enable a person skilled in the art to make or use the invention. Because patents are presumed valid, lack of enablement must be proven by clear and convincing evidence.

132. A person having ordinary skill in the art would not have understood that the patentee was in possession of an apparatus that, on the receiving portion of the transceiver, determined a SNR margin for each subchannel and assigned the number of bits to be used on each subchannel based on this SNR margin, as discussed above. Thus, claim 10 lacks enablement.

B. Claim 16 of the ’988 Patent Does Not Meet the Written Description and/or Enablement Requirements of 35 U.S.C. § 112, First Paragraph

1. Written Description Requirement

133. Claim 16 requires “a first plurality of bits from a first carrier using a first Signal to Noise Ratio (SNR) margin,” “a second plurality of bits from a second carrier using a second SNR margin,” a “third plurality of bits from the ***first carrier*** using a third SNR margin,” “wherein the first SNR margin is different than the second SNR margin,” “wherein the first SNR margin is different than the third SNR margin,” and “wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another.” ’988 Patent at 11:19-12:7 (emphasis added).

134. The ’988 Patent specification does not give the term “carrier” any special meaning. One of ordinary skill in the art would therefore read the term “carrier,” as used in claim 16, in the singular to mean a single carrier (or subchannel). By contrast, the plural form of carriers means multiple subcarriers or “multiple subchannels,” as described in the specification. *Id.* at 1:31-37.

135. As a result, one of ordinary skill in the art would not understand how the first carrier (singular) could concurrently have a first and a third SNR margin and two different pluralities of bits. The specification fails to describe or imply how a single carrier can support two different SNR margins and/or two different pluralities of bits concurrently.

136. Alternatively, if Plaintiff claims that the two (or all three) SNR margins with their different plurality of bits do not occur concurrently but, instead, occur one-after-the-other in a serial fashion, the specification fails to describe any temporal aspect as to how the same first carrier changes its SNR margin and the plurality of bits from a first to a different third value.

137. Thus, claim 16 of the ’988 Patent lacks written description.

2. Enablement Requirement

138. Prior to April 18, 2000, it was known that SNR Margins could vary from carrier to carrier. *See e.g.,* Cai at 3:4-14; Peeters at 3:16-24, Figs. 4 and 5. Likewise, bit allocation was a well-known concept. *See e.g.,* Peeters at 3:16-24; Kapoor at 8:39-42, 10:36-46.

139. A person of ordinary skill in the art, however, would not have understood that the patentee was in possession of an apparatus that concurrently has a first and a third SNR Margin and two different pluralities of bits on the same carrier.

140. Thus, claim 16 of the ’988 Patent lacks enablement.

XII. ANALYSIS OF THE PRIOR ART

A. ’354 Patent

1. European Patent Application No. 0,753,948 to Peeters (“Peeters”)

141. Peeters discloses each element of claim 10 of the ’354 Patent.

a. Brief description of Peeters

142. European Patent Application No. 0,753,948 to Peeters is titled “Capacity allocation for OFDM.” Peeters was filed on July 11, 1995 and published on January 15, 1997. I understand that Peeters therefore constitutes prior art to the ’354 Patent under 35 U.S.C. §§102(a) and (b).

143. Peeters discloses a method that can be used with discrete-multitone (DMT) modulation. Peeters at 3:47-58, claim 11. The method relates to allocating data elements to a set of carriers wherein each carrier has an associated signal noise ratio margin. *Id.* at 2:3-5, claim 9.

b. Claim 10

144. Claim 10 of the ’354 Patent is disclosed in view of Peeters.

c. Claim 10.pre "A multicarrier communications transceiver operable to:"

145. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Peeters discloses Claim 10.pre "A multicarrier communications transceiver operable to." Peeters is used in ADSL applications but can also be implemented in DMT systems. *Id.* at 7:54-57, 3:47-58, claim 11. Peeters describes a modem "which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies." *Id.* at 2:8-9. "The modem includes a system for variably allocating data elements or data, and power to the 10 carrier frequencies to be transmitted via a telephone line." *Id.* at 2:9-10.

146. Peeters discloses the preamble of claim 10, to the extent it is limiting.

d. Claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers"

147. Peeters discloses claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers."

148. Peeters discloses transmitting and receiving a multicarrier symbol that comprises a set of 256 (plurality) of carriers. Peeters specifically references "the draft ANSI standard on ADSL" that has requirements for transmitting and receiving a multicarrier symbol with a plurality of carriers with at least:

> According to the draft ANSI standard on ADSL, mentioned already in the introductory part, the Discrete Multi Tone modulator MOD modulates data elements applied to its first input Ml1 on a set of 256 carriers having equidistant frequencies, and further applies the modulated carriers **via its output MO to a twisted pair telephone line**, not shown in the figure.

Id. at 4:35-38.

> Due to the effective impulse response length of the transmission line however, intersymbol interference will occur. Such intersymbol interference can be compensated by an adaptive filter **at the receiver's side**. In known solutions and

> **also suggested in paragraph 6.10 of the above cited draft Standard**, such a digital filter technique at the **receiver's side** is combined with cyclic prefix extension at the **transmitter's side** to obtain sufficient intersymbol interference compensation.

Id. at 4:52-56.

149. Peeters describes a method wherein the data and power are allocated for each carrier frequency by "measuring for each carrier frequency the signal noise ratio (SNR)." *Id.* at 2:10-13. The "equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation." *Id.* at 2:13-16. "The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity." *Id.* at 2:19-21. All data elements are treated in an identical way, however, several types of data, each of which characterized by its own requirements and specifications, can be distinguished. *Id.* at 2:21-25.

150. Peeters further discloses that each "group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors . . . Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data." *Id.* at 2:33-38.

151. Peeters further discloses that subsets of carrier groups can be grouped together and assigned certain data:

> To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier

> criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. **4 carriers is then associated with a first group of data elements**, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise 20 compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and there-fore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed

Id. at 3:16-24.

152. Peeters therefore discloses receiving a multicarrier symbol comprising a first plurality of carriers wherein this subset of carriers *e.g.,* 4 carriers, is associated with a first group of data elements. *See id.*

153. Thus, Peeters discloses claim 10.a.

e. Claim 10.b "and a second plurality of carriers"

154. Peeters discloses claim 10.b "and a second plurality of carriers":

> To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. **7 carriers is associated with a second group of data elements** having e.g. lower noise 20 compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and there-fore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed

Id. at 3:16-24.

155. As described in the passage above, Peeters also discloses claim 10.b, wherein this second subset of carriers e.g., 7 carriers, is associated with a second group of data elements.

156. Figure 1 and Figure 2 and their associated text further disclose a first and a second plurality of carriers as demonstrated by the first plurality of carriers having only interleaved data and a second plurality of carriers having only fast data with:

> The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to **classify the data elements in 2 groups**: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to **burst error correction** for the data elements as well as to **acceptable latency**. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors.

Id. at 5:38-44.

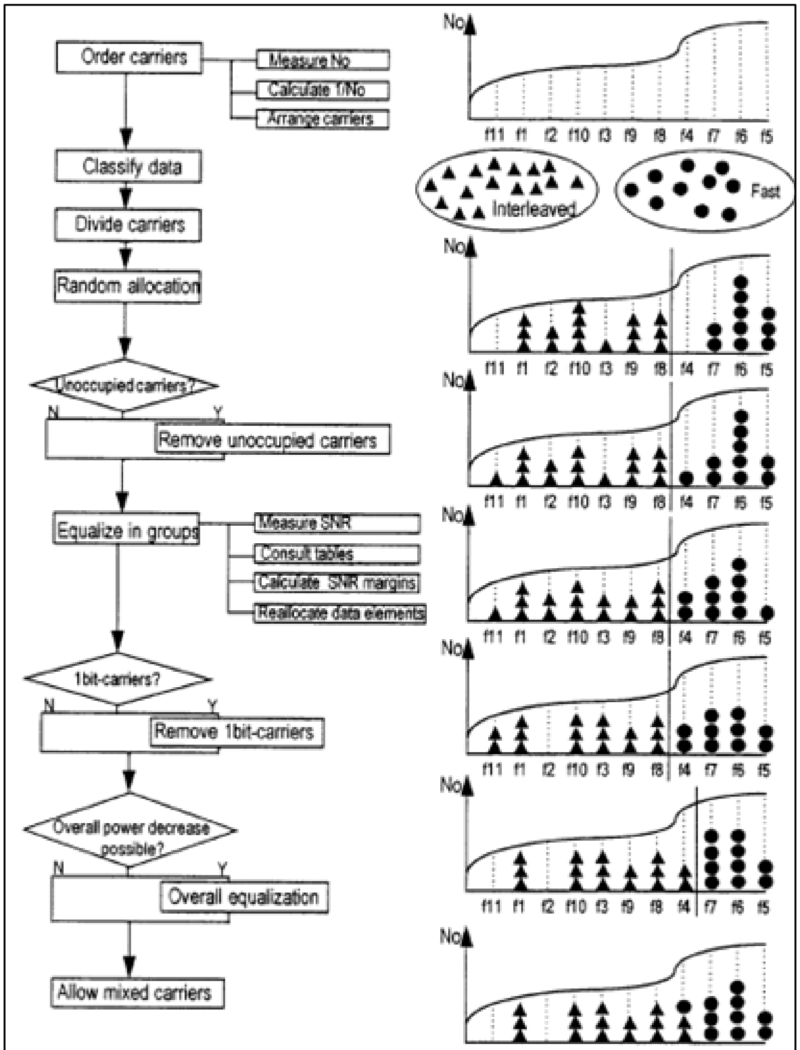


Fig. 2

Id. at Fig. 2; *see also id.* at Fig. 1.

157. Peeters further discloses an alternative implementation where the overhead data, as opposed to interleaved data, can constitute the first group of data elements while the user data, as opposed to fast data, can constitute the second group of data elements, wherein the user data is allocated to carriers different from the carriers occupied by the overhead data. *Id.* at 8:3-6.

158. In regard to Figure 2 above, the last step shows that f4 is a "mixed carrier" with one solid dot and two solid triangles. A person of ordinary skill in the art would have understood Peeters to disclose this last step as optional, and therefore the system of Peeters could assign carriers to subset 1 or subset 2 without any mixed data. *See id.* at 3:20-24. ("Once having allocated

the data elements, the fourth carrier of the first subset however ***may be*** partially unoccupied by data elements of the first group and therefore ***can be used*** as a mixed carrier, to which also data elements of the second group are allocated.") (emphasis added). Thus, Peeters discloses the option wherein each carrier carries only one data type.

159. Thus, Peeters discloses claim 10.b.

f. Claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin"

160. Peeters discloses claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin."

161. The Court has construed "SNR margin" as "a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

162. Peeters meets the Court's definition for SNR margin. For the SNR required to maintain a specified BER, Peeters discloses:

> Obviously, this is equal to measuring for each carrier frequency **the signal noise ratio (SNR) provided** that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, **the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER)** to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation.
>
> As stated on lines 26-27 of column 11 of US Patent 4,679,227, **these signal noise ratios** necessary for transmission of the data elements **are well known in the art**, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. **In this way, the known method and modem provide a data element allocation to compensate for equivalent noise**

> **and to maximize the overall data transmission rate**. The known method and modem however treat all data elements in an identical way.

Id. at 2:11-22

163. For the SNR margin, Peeters discloses an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link. This extra SNR requirement is based on e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, . . . with at least:

> In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished.
>
> An object of the present invention is to provide a method and equipment of the above known type but which take into account data depending requirements for noise compensation, transmission rate and so on, and **wherein data element allocation and transmission for each type of data are thus tuned to its own specifications.**
>
> According to the invention, this object is achieved in the method, mapping unit and modulator described in claims so 1, 13 and 14 respectively. Indeed, in the method described in claim 1, **data elements are, according to a predetermined data criterion**, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, . . . or a combination thereof, classified into **N groups of data elements**. Each group of data elements becomes modulated on a subset of carriers, **these carriers being selected out of the full available set of carriers in accordance with another specific criterion**, called a **predetermined carrier criterion**, e.g. **the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ...** Based on the relation between data and carrier criteria, the **N groups of data elements are linked one by one to the N subsets of carriers**. In this way, the **carrier specific properties are tuned in to the requirements for transmission of specific groups of data**.
>
> In addition, **by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table**, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, **noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table** which renders the allocation method more accurate.

> A further feature of the present data allocation method is that in a particular first implementation thereof, **the predetermined data criterion is equal to service dependent required compensation for occasional noise increase**. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The **predetermined carrier criterion** in this first implementation **is defined as the sensitivity of a carrier for such occasional noise increase.**

Id. at 2:26-47.

164. Peeters describes performing the calculations for each carrier using the measured SNR and the SNR margin with:

> These SNR margins are first calculated for each carrier in subset 1 **by subtracting the requested SNR from the SNR value measured on each of these carriers.** Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. **As a result, the SNR margin for f1 equals 2 dB**. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5.

Id. at 6:59 – 7:10.

165. As discussed above, the transmitter's **input data elements are classified into two groups** based on the requirements with respect to interleaving and fast data. *Id.* at 6:23-24. "Once classified, each data element can be considered to carry a label defining whether it forms part of the group of interleaved data or of the group of fast data." *Id.* at 6:25-26. **The carriers are then divided into two subsets**. *Id.* at 6:30. Next, the method considers "the carriers f1 . . . f 11 being arranged in decreasing order of noise sensitivity," and "the third step is executed by defining the last carrier in the sequence which belongs to subset 1. In the corresponding graph in the right part of Figure 2, a **vertical line is drawn to separate subset 1 carriers from subset 2 carriers**.

Subset 1 is constituted by carriers f11, f1, f2, f10, f3, f9 and f8, whilst subset 2 contains carriers f4, f7, f6 and f5." *Id.* at 6:33-37, Fig. 2. Therefore, in this example, the first plurality of carriers is defined as subset 1 and the second plurality of carriers is defined as subset 2.

166. Peeters further discloses equalization of the data element allocations within each group. *Id.* at 7:11. In order to maximize the minimum SNR within the first group of carriers, data elements of the first group are removed from carriers of subset 1 having a lower SNR margin and allocated to other carriers of subset 1 that have a higher SNR margin. *Id.* at 7:4-19. Once the data element distribution is performed, an optimal data bit allocation is now obtained, i.e., an allocation is found with maximal minimum SNR margins. *Id.* at 7:26-32.

167. A person of ordinary skill in the art would have understood that the system of Peeters describes bit allocation wherein a first plurality of carriers will have a first SNR margin and receive a first plurality of bits based on the SNR logic.

168. As discussed above for element 10.a, incorporated herein, Peeters discloses that both a transmitter and receiver are included in the invention. Therefore, these plurality of carriers and bit allocations would be transmitted by the transmitter portion of the transceiver and the same carriers and bit allocations would be received by the receiver portion of the transceiver.

169. Thus, Peeters discloses claim 10.c.

g. Claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin"

170. Peeters discloses claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin."

171. As discussed above for element 10.c, incorporated herein, Peters discloses receiving a second plurality of carriers defined as subset 2 and subset 2 has a second plurality of bits based on the SNR margins for subset 2.

172. Thus, Peeters discloses claim 10.d.

h. <u>Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers,"</u>

173. Peeters discloses claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers".

174. As discussed above for at least element 10.c, incorporated herein, Peeters discloses that the subset 1 carriers, i.e., the interleaved data group, has different SNR margins than the subset 2 carriers, i.e., the fast data group. *Id.* at 3:14-24 ("A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements."). As also shown above, Peeters lists the full set of carriers where the carrier numbers assigned to subset 1 are different than the carrier numbers assigned to subset 2.

175. Peeters further discloses that overhead data, as opposed to interleaved data, can constitute the first group of data elements whilst user data, as opposed to fast data, can constitute the second group of data elements, wherein the user data is allocated to carriers different from the carriers occupied by the overhead data. *Id.* at 8:3-6. This alternative example would also produce two subsets of different carriers.

176. Thus, Peeters discloses claim 10.e.

i. <u>Claim 10.f "wherein the first SNR margin is different than the second SNR margin"</u>

177. Peeters discloses claim 10.f "wherein the first SNR margin is different than the second SNR margin".

178. As discussed above for at least element 10.c, incorporated herein, Peeters discloses that the subset 1 carriers, i.e., for the interleaved data group, will have a different SNR margin than the subset 2 carriers, i.e., the fast data group because each type of data has different SNR

margin requirements. These two types of data and their unique requirements are described with at least:

> The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to **classify the data elements in 2 groups**: a group of **interleaved data** and a group of **fast data**. The classification is performed **based upon the requirements with respect to burst error correction for the data elements as well as to acceptable latency**. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be **allocated to carriers with a high sensitivity for burst errors** since for these carriers, protection by interleaving is provided. On the contrary, **data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive**, will not be interleaved but **can be allocated to carriers which are less sensitive for burst errors**.

Id. at 5:38-44.

179. Peeters discloses that the first SNR margin is different than the second SNR margin with at least Figure 4 and its associated text. In the annotated Figure 4 shown below, the table on the left is for the subset 1 carriers and the table on the right is for the subset 2 carriers. *Id.* at 6:57-58. The "Requested SNR (dB)" shown in the right-hand heading of each table is the "SNR margin" as construed by the Court. *Id.* at 6:59-7:2 ("These SNR margins are first calculated for each carrier in subset 1 by subtracting the **requested SNR** from the **SNR value measured** on each of these carriers."). Figure 5, also shown below, shows the measured SNR values. *Id.* at 6:58-59, Fig. 5. The table on the left lists five different values for the "first SNR margin." *Id.* at Fig. 4. The table on the right lists 5 different values for the "second SNR margin." *Id.* A comparison of the values listed for the first and second SNR margins shows that all the values listed for the first SNR margin are different than all the values listed for the second SNR margin. *Id.* Specifically, Subset 2 does not include the values 16, 20, 23 or 25. *Id.*

180. Alternatively, if the Court determines that the SNR margin for the first plurality of carriers needs to be the same value and the SNR margin for the second plurality of carriers also needs to be the same value but different a different value than the first SNR, Peeters also discloses

this configuration with the first two carriers listed for subset 1 and subset 2. Specifically, the first plurality of carriers would have a SNR margin of 16 and the second plurality of carriers would have a SNR margin of 15.

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Subset 1

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Subset 2

Fig. 4

Id. at Fig. 4 (annotated).

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

Id. at Fig. 5 (annotated).

181. Thus, Peeters discloses claim 10.f.

j. <u>Claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."</u>

182. Peeters discloses claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

183. As discussed above for at least element 10.c and below, incorporated herein, Peeters discloses that the two types of data assigned to the carriers in subsets 1 and 2 are matched up with carriers that best support the requirements of the data. The interleaved data channels in subset 1 are channels that are more robust than the channels in subset 2 because, as described below, the carriers in subset 1 are assigned to channels with "a high sensitivity for burst errors" and the carriers in subset 2 are assigned "to carriers which are less sensitive for burst errors" (less robust).

> The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to **classify the data elements in 2 groups**: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to burst error correction for the data elements as well as to **accep**table latency. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore **will be allocated to carriers with a high sensitivity for burst errors** since for these carriers, protection by interleaving is provided. On the contrary, **data such as telephone speech data**, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved **but can be allocated to carriers which are less sensitive for burst errors**.

Id. at 5:38-44.

184. As discussed above, Peeters discloses a first subset of carriers having one SNR margin and a second subset of carriers having a second SNR margin. A person of ordinary skill in the art would have understood that the first SNR margin of the subset of carriers can be set higher using the 'required SNR per data element' table. *See* annotated Figs. 4 and 5 above. For instance, a person of ordinary skill in the art could require the first subset of carriers to have a higher requested SNR that results in a higher SNR margin on the first subset of carriers.

185. And because the SNR margins are not the same, it is inherent that the first SNR margin, if higher, is more robust. Thus, Peeters discloses claim 10.g.

186. Consequently, claim 10 is disclosed by Peeters.

2. U.S. Patent No. 6,205,410 to Cai ("Cai") in View of Peeters

187. Cai in view of Peeters renders obvious each element of claim 10 of the '354 Patent.

a. Brief Description of Cai

188. U.S. Patent No. 6,205,410 to Cai is titled "System and Method for Bit Loading with Optimal Margin Assignment." Cai issued on March 20, 2001, from a patent application that was filed on October 13, 1998, and claims a priority to U.S. Provisional Patent Application Ser. No. 60/087570, dated June 1, 1998. I understand Cai therefore constitutes prior art to the '354 Patent under 35 U.S.C. § 102 (e).

189. Further, the '354 Patent specification cites Cai in the references cited section. Thus, the Applicant understood, and admitted, that Cai is material prior art to the '354 Patent. The prosecution history, however, clearly shows that the examiner failed to consider Cai. As discussed below, had the examiner considered Cai in view of Peeters, the examiner would have found that each element of claim 10 of the '354 Patent is disclosed.

190. Cai describes a DMT multicarrier transceiver that modulates and demodulates a plurality of bits over a plurality of carriers. Cai at 1:12-13 ("this invention relates to the field of discrete multi-tone (DMT) data communication"), 1:19-22 ("In data communications using discrete multitone (DMT) technology, a serial data bit stream to be communicated is distributed among multiple channels and transmitted in parallel from a transmitting modem to a receiving modem."). Cai further describes a system and method which establishes an optimum margin for each channel in a discrete multi-tone DMT transceiver. *Id.* at Abstract.

191. Like the problem described in the '354 Patent, Cai describes a problem in the prior art wherein a common margin, typically 6 dB, is applied to each channel to obtain a transmission signal-to-noise ratio at which to achieve a bit error rate of approximately 10^{-7}. *Id.* at 1:44-48, 2:62-3:3, Fig. 1. Cai describes the problem with using this conventional approach:

> Such conventional approaches suffer from the subtraction of a common margin from all of the measured signal-to-noise ratios of each channel. It is automatically assumed that the common 6 dB margin is appropriate to compensate for the variation in the signal-to-noise ratio for each channel. However, some channels may experience greater variation in the signal-to-noise ratio than others. Thus, in some cases the common margin may be too great, resulting in a bit rate that is unnecessarily slow. In other cases the common margin may be too small, resulting in a bit rate that is too high which translates into an unnecessarily high bit error rate.

Id. at 1:51-62.

192. The objective of the invention in Cai is to provide for a DMT modem which establishes an optimum margin for each DMT channel, (*id.* at 1:65-67):

> Turning then, to FIG. 2, shown is a graph 60 which details the SNR of the channels of a DMT data link according to the present invention. Once again, for each DMT channel, a measured SNR 53 is shown. However, the SNR margins employed vary from channel to channel, depending upon the potential SNR variation experienced during the connection. For example, a large margin 63 is used in channel 4, whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate.

Id. at 3:4-14.

b. <u>Brief Description of Peeters</u>

193. I provided a brief description of Peeters above. *See supra*, § XII.A.1.a, which I incorporate by reference here.

c. <u>Motivations to Combine Cai in view of Peeters</u>

194. A person of ordinary skill in the art would have been motivated to combine the disclosure of Cai with Peeters because they both describe methods to obtain optimal data bit allocation/SNR Margins. *See e.g.*, Peeters at 7:26-32; Cai at 4:31-35.

195. A person of ordinary skill in the art would have understood that both Cai and Peeters techniques are designed to work with DMT systems. *See* Peeters at 7:54-57, 3:47-58, claim 11; Cai at Abstract. Because of this, one of ordinary skill in the art would have considered these references together.

196. Cai's objective is to optimize the margin of each subcarrier used by a DMT system in order to provide an optimum bit rate. *See*, *e.g.*, Cai at Abstract, 1:51-62, 9:46-49. Cai is exactly the type of reference a skilled artisan would have sought because Cai describes how to determine the optimum margin for each subchannel of a DMT system. Specifically, Cai describes a DMT system in which each subcarrier potentially suffers from a different variation in SNR. *Id.* at 3:7-13. The margin used for each subchannel is proportional to its SNR variation (the difference between the maximum observed SNR and the minimum observed SNR), so that a subchannel with a large swing in its SNR over time is used with a larger margin than a subchannel with a small swing in its SNR. *Id.* Cai discloses that "the optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while ensuring a desired bit error rate which is, for example, 10-7." *Id*. at 9:46-49. Cai describes several alternatives for SNR variation logic that "is executed at predetermined times to ascertain the variation of the signal-to-noise ratio for each individual DMT channel from which the margin for each channel is calculated." *Id.* at 5:5-8; *see also, e.g., id*. at 6:61-9:49.

197. The primary difference between Peeters and Cai is that Peeters suggests dividing subsets of carriers based on the type of data element grouping. *See* Peeters at 6:24-50. Although Cai is directed towards optimizing SNR margins on each carrier, Cai discloses that the SNR can be the same on more than one carrier, in addition to being different than the other carriers. *See e.g.,* Cai at Fig. 2, 3:7-13, 9:45-48. One of ordinary skill in the art would have understood that the carriers in Cai's DMT system could be divided into subsets of carriers where each subset would have the same SNR margin. A person of ordinary skill in the art would have also found this modification trivial, particularly because Peeters discloses that different margins can be used for different subchannels, and Cai discloses that the SNR variation logic can determine the

optimum margin for each subchannel. Thus, a person of ordinary skill in the art would have had reasonable expectations of success in combining the teachings of Peeters' with Cai's technique of optimizing the SNR margin on each carrier.

d. Claim 10

198. Cai in view of Peeters discloses each element of claim 10 of the '354 Patent.

e. Claim 10.pre "A multicarrier communications transceiver operable to:"

199. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Cai discloses Claim 10.pre "A multicarrier communications transceiver operable to." As discussed above, Cai describes a DMT multicarrier transceiver that modulates and demodulates a plurality of bits. Cai at 1:12-13 ("this invention relates to the field of discrete multi-tone (DMT) data communication"), 1:19-22 ("In data communications using discrete multitone (DMT) technology, a serial data bit stream to be communicated is distributed among multiple channels and transmitted in parallel from a transmitting modem to a receiving modem."). Cai further describes a system and method which establishes an optimum margin for each channel in a discrete multi-tone DMT transceiver. *Id.* at Abstract.

200. Cai also discloses a discrete multitone (DMT) data link which "communicates across a communications channel" and is understood that the "functionality of the transmitter 103 and receiver 106 are generally combined in a single DMT modem so that it may transmit and receive data communication to and from other modems." *Id.* at 3:14-24; *see also id.* at 1:67-2:13, 4:51-54.

201. Thus, Cai discloses the preamble of claim 10, to the extent it is limiting.

202. As discussed above in § XII.A.1.c, and incorporated herein, Peeters also discloses the preamble of claim 10, to the extent it is limiting. Thus, Cai in view of Peeters further discloses the preamble of claim 10, to the extent it is limiting.

f. Claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers"

203. Cai discloses claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers."

204. Cai discloses a "receiver 106 [which] . . . **receives the DMT signal** from the inverse fast Fourier transform block 126 at the time domain equalizer block 129." *Id.* at 3:33-35. Cai further discloses "a serial data stream enters the bit allocation block 116 [labelled 113 in Fig. 3] where the serial data to be transmitted is distributed among multiple DMT channels, each DMT channel corresponding to an individual quadrature amplitude modulation block [QAM $119_{1..n}$]." *Id.* at 3:51-56. These QAM blocks "generally produce a demodulated tone which is then scaled based upon a desired signal-to-noise ratio for each individual DMT channel in the tone scaling block 123 according to the tone scaling table 169." *Id.* at 3:61-64. "The multiple DMT channels are then combined by the inverse fast fourier transform block 126 **and transmitted across the channel 109 to the time domain equalizer block 129 of the receiver 106.**" *Id.* at 3:65-4:2. Cai further discloses that the "overall margin is an average of the margins for each channel in the timed domain." *Id.* at 5:20-22. A person of ordinary skill in the art would have realized that any two or more of these multiple carriers could be grouped together to make a first plurality of carriers and two or more of the remaining carriers could be grouped together to make a second plurality of carriers. Cai therefore discloses a system wherein a plurality of carriers, or channels, are grouped by time domain.

205. Thus, Cai discloses claim 10.a.

206. As discussed above in § XII.A.1.d, and incorporated herein, Peeters also discloses transmitting and receiving a multicarrier symbol that comprises a set of 256 (plurality) of carriers. Peeters specifically references "the draft ANSI standard on ADSL" that has requirements for transmitting and receiving a multicarrier symbol with a plurality of carriers with at least:

> According to the draft ANSI standard on ADSL, mentioned already in the introductory part, the Discrete Multi Tone modulator MOD modulates data elements applied to its first input Ml1 on a set of 256 carriers having equidistant frequencies, and further applies the modulated carriers **via its output MO to a twisted pair telephone line**, not shown in the figure.

Id. at 4:35-38.

> Due to the effective impulse response length of the transmission line however, intersymbol interference will occur. Such intersymbol interference can be compensated by an adaptive filter **at the receiver's side**. In known solutions and **also suggested in paragraph 6.10 of the above cited draft Standard**, such a digital filter technique at the **receiver's side** is combined with cyclic prefix extension at the **transmitter's side** to obtain sufficient intersymbol interference compensation.

Id. at 4:52-56.

207. And because Cai discloses that one or more channels (or carriers) can have the same SNR margin that is different than other SNR margins in the system, Cai at Figure 2, a person of ordinary skill in the art would have understood to apply Cai's varying SNR margin technique to each subdivided carrier disclosed in Peeters to optimize the DMT system. *See* Cai at 3:7-13, 2:4-21, 4:31-35. Thus, Cai in view of Peeters further discloses claim 10.a.

g. <u>Claim 10.b "and a second plurality of carriers"</u>

208. As discussed above with claim 10.a, Cai discloses claim 10.b "and a second plurality of carriers."

209. Cai discloses a system with a plurality of carriers, or channels, wherein the "SNR margins employed vary from channel to channel, depending upon the potential SNR variation

experienced during the connection." *Id.* at 3:3-8. Figure 2 shows a plurality of carriers having their own SNR margin:

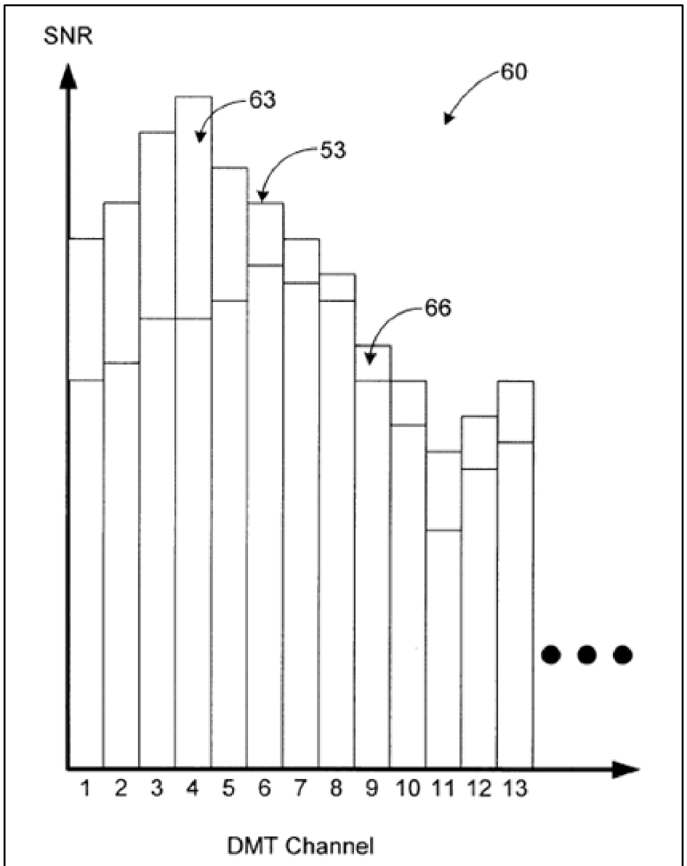


Fig. 2

Id. at Fig. 2.

210. A person of ordinary skill in the art would have understood that Cai discloses a first plurality of carriers having the same SNR margin that is different than a second plurality of carriers having a different SNR margin. For instance, a person of ordinary skill in the art would have understood that Cai discloses a system wherein channels, or at least carriers 6 and 13 of Figure 2 comprise a first plurality of carriers having the same SNR margin, and channels, or at least carriers 7 and 10, comprise a second plurality of carriers having the same SNR margin as shown in the annotated Figure 2 below.

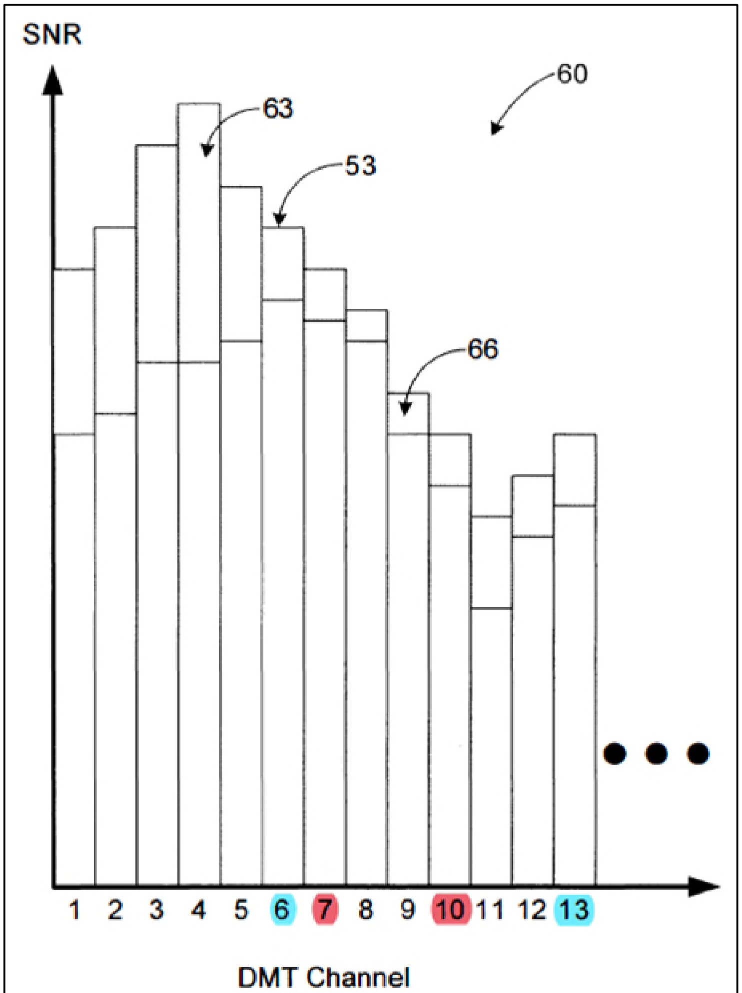


Fig. 2

Id. at Fig. 2 (annotated).

211. Thus, Cai discloses claim 10.b.

212. As discussed above in § XII.A.1.e, and incorporated herein, Peeters also discloses that subsets of carrier groups can be grouped together and assigned certain data. Peeters at 3:16-24 ("[a] **first subset** of e.g. 4 carriers is then associated with a first group of data elements, a **second subset** of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on."). A person of ordinary skill in the art would have understood that Peeters' method can be applied in Cai's DMT system to allocate a first and a second group of data elements (i.e., based on pre-

determined criteria) to a first and a second plurality of carriers, respectively. And because Cai discloses that one or more channels (or carriers) can have the same SNR margin that is different than other SNR margins in the system, Cai at Figure 2, a person of ordinary skill in the art would have understood to apply Cai's varying SNR margin technique to the subdivided carriers disclosed in Peeters to optimize the DMT system. *See* Cai at 3:7-13, 2:4-21, 4:31-35. Thus, Cai in view of Peeters further discloses claim 10.b.

h. **<u>Claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin;"</u>**

213. Cai discloses claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin."

214. Cai is directed toward a system and method having "operating logic [which] includes bit allocation logic and signal-to-noise (SNR) variation logic." *Id.* at 2:4-5. "The SNR variation logic determines an variation in the Signal-to-noise ratio for each channel. The bit loading logic then determines a bit loading configuration based upon the variation in the Signal to-noise ratio ascertained by the SNR variation logic." *Id.* at 2:5-9. Cai discloses three SNR variation logics that each achieve "precise bit allocation and tone scaling . . . based upon the SNR estimate and the optimum margin estimate determined from the SNR variation in the bit loading block 156 at the startup of data communication." *Id.* at 4:31-35; *see also id.* at 2:14-21. The "actual distribution of the data input 113 among the multiple DMT channels by the bit allocation block 116 is performed pursuant to the bit allocation table 116." *Id.* at 4:36-39.

215. As a result of the SNR logic, the "optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while ensuring a desired bit error rate which is, for example, 10^{-7}." *Id.* at 9:45-48.

216. The SNR margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13.

217. A person of ordinary skill in the art would have understood that the system of Cai describes bit allocation wherein a first plurality of carriers will have a first SNR margin and receive a first plurality of bits based on the SNR logic. For example, channels 6 and 13, as the first plurality of carriers, would be assigned the first plurality of bits based on their SNR margin.

218. Thus, Cai discloses claim 10.c.

219. As discussed above in § XII.A.1.f, and incorporated herein, Peeters also discloses claim 10.c. A person of ordinary skill in the art could have applied the method described in Peeters, wherein the incoming data elements are classified (by type or pre-determined criteria) and are grouped into subsets of carriers. Peeters at 6:23-50. Once the data elements are assigned to the two subsets of carriers, the measured SNR values for each of the individual carriers is calculated and used to determine the bit allocation for the first and the second plurality of carriers, respectively. *Id*. at 6:51-7:10. A person of ordinary skill in the art would have understood that the carriers in Cai could be grouped into subsets by the techniques of Peeters, and then the technique in Cai could be applied to optimize the SNR margins for each plurality of carriers. *See* Cai at 3:7-13, 2:4-21, 4:31-35. Thus, Cai in view of Peeters further discloses claim 10.c.

i. <u>Claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin;"</u>

220. Cai discloses claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin."

221. Cai is directed toward a system and method having "operating logic [which] includes bit allocation logic and signal-to-noise (SNR) variation logic." *Id.* at 2:4-5. "The SNR variation logic determines an variation in the signal-to-noise ratio for each channel. The bit loading logic then determines a bit loading configuration based upon the variation in the signal to-noise ratio ascertained by the SNR variation logic." *Id.* at 2:5-9. Cai discloses three SNR variation logics that each achieve "precise bit allocation and tone scaling . . . based upon the SNR estimate and the optimum margin estimate determined from the SNR variation in the bit loading block 156 at the startup of data communication." *Id.* at 4:31-35; *see also id.* at 2:14-21. The "actual distribution of the data input 113 among the multiple DMT channels by the bit allocation block 116 is performed pursuant to the bit allocation table 116." *Id.* at 4:36-39.

222. As a result of the SNR logic, the "optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while ensuring a desired bit error rate which is, for example, 10^{-7}." *Id.* at 9:45-48.

223. The SNR margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13.

224. As discussed above, a person of ordinary skill in the art would have understood that the system of Cai describes bit allocation wherein a second plurality of carriers will have a second SNR margin and receive a second plurality of bits based on the SNR logic. Because Cai discloses a first and a second plurality of carriers, each having their own SNR margin, Cai necessarily discloses that the plurality of bits are different between the first and the second plurality of carriers. *See* annotated Fig. 2 above. For example, channels 7 and 10, as the second

plurality of carriers, would be assigned a second plurality of bits based on their different SNR margin.

225. Thus, Cai discloses claim 10.d.

226. As discussed above in § XII.A.1.f, and incorporated herein, Peeters also discloses claim 10.d. A person of ordinary skill in the art could have applied the method described in Peeters, wherein the incoming data elements are classified (by type or pre-determined criteria) and are grouped into subsets of carriers. Peeters at 6:23-50. Once the data elements are assigned to the two subsets of carriers, the measured SNR values for each of the individual carriers is calculated and used to determine the bit allocation for the first and the second plurality of carriers, respectively. *Id*. at 6:51-7:10. A person of ordinary skill in the art would have understood that the carriers in Cai could be grouped into subsets by the techniques of Peeters, and then the technique in Cai could be applied to optimize the SNR margins for each plurality of carriers. *See* Cai at 3:7-13, 2:4-21, 4:31-35. Thus, Cai in view of Peeters further discloses claim 10.d.

j. <u>Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers,"</u>

227. Cai discloses claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers."

228. As shown above in annotated Figure 2, the first plurality of carriers could be channels 6 and 13 and the second plurality of carriers could be channels 7 and 10. Thus, channels 6 and 13 are different than channels 7 and 10.

229. During start up, "the bit allocation logic 223 is executed, thereby establishing the bit loading configuration to be used by the second DMT modem 233 in transmitting a modulated data Signal to the DMT modem 200. The SNR variation logic 226 is executed at predetermined

times to ascertain the variation of the signal-to-noise ratio for each individual DMT channel from which the margin for each channel is calculated." *Id.* at 5:1-8.

230. The SNR margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. Thus, the different margins can support a different number of bits. This is further evidenced in Figure 2:

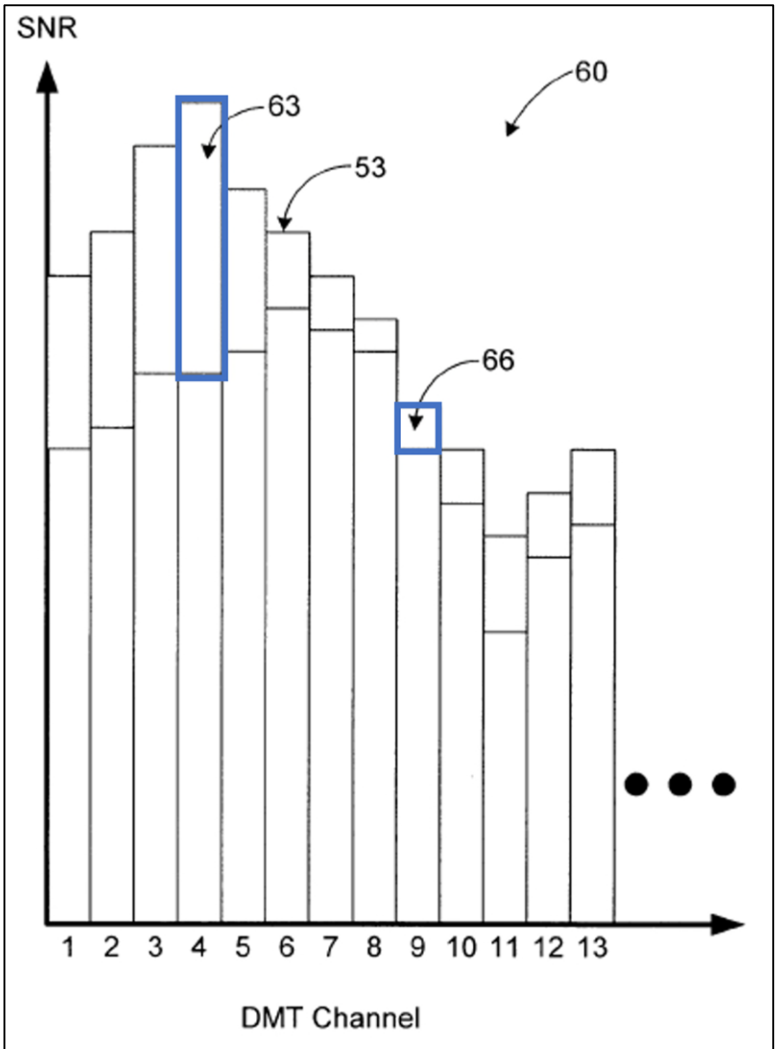


Fig. 2

Id. at Fig. 2 (annotated).

231. As a result of channels having different SNR margins, it is inherent that the system of Cai discloses a first plurality of carriers that is different than a second plurality of carriers. For example, the SNR for the first plurality of channels 6 and 13 is different than the SNR for the second plurality of channels 7 and 10. This example can be extended for two or more channels that have the same SNR as channel 4 as the first plurality of channels and for two or more channels with the same SNR as channel 9 as the second plurality of channels. Additionally, a person of ordinary skill in the art would have understood that in the system of Cai, any two or more channels can have the first same SNR and two or more remaining channels can have the second same SNR.

232. Thus, Cai discloses claim 10.e.

233. As discussed above and incorporated herein, Peeters also discloses that subsets of carrier groups can be grouped together and assigned certain data. Peeters at 3:16-24 ("[a] first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise compensation requirements than the first group of data elements, and so on."). A person of ordinary skill in the art would have understood that the plurality of carriers in Cai that have the same SNR margin would be assigned the same bits during bit allocation, and therefore, would comprise a first plurality of carriers with bit allocations that are different than the second plurality of carriers. Thus, Cai in view of Peeters further discloses claim 10.e.

k. <u>Claim 10.f "wherein the first SNR margin is different than the second SNR margin,"</u>

234. Cai discloses claim 10.f "wherein the first SNR margin is different than the second SNR margin."

235. As clearly shown by annotated Figure 2 above and described by its supporting text, the SNR of the first plurality of channels 6 and 13 is different than the SNR for the second plurality

of channels 7 and 10. Additionally, a person of ordinary skill in the art would have understood that in the system of Cai, any two or more channels can have the first same SNR and two or more of the remaining channels can have the second same SNR.

236. Cai is directed toward a system where SNR margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. This is further evidenced in Figure 2:

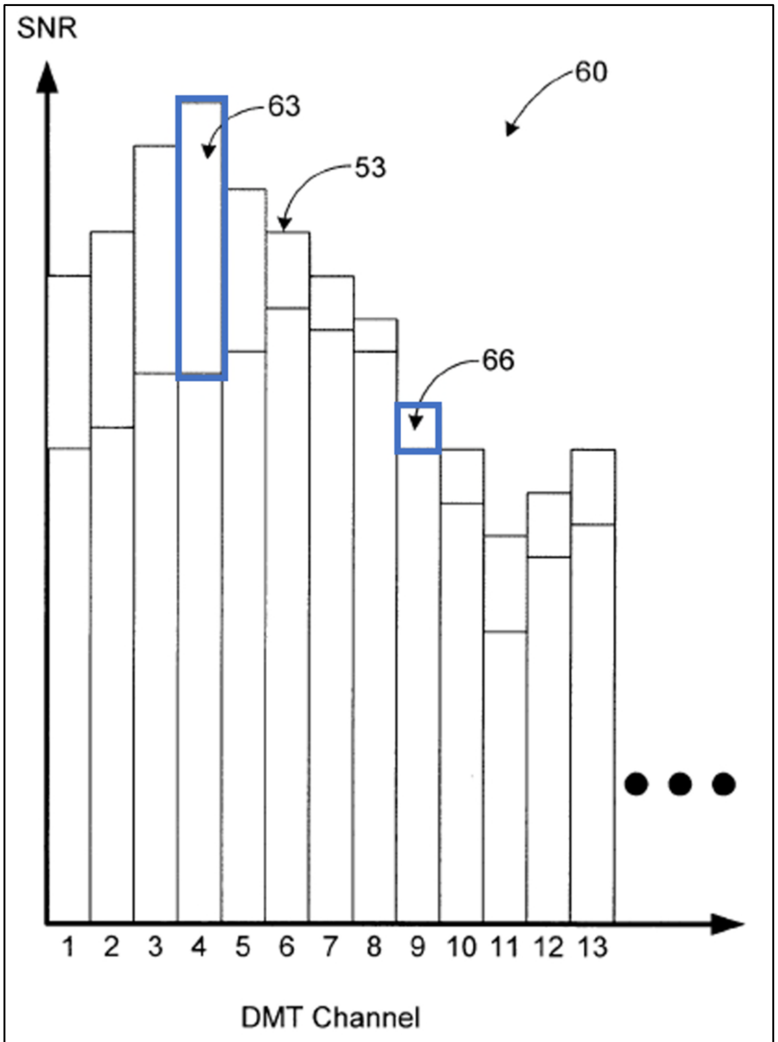


Fig. 2

Id. at Fig. 2 (annotated).

237. Thus, Cai discloses claim 10.f.

238. As discussed above in § XII.A.1.i, and incorporated herein, Peeters also discloses claim 10.f. Thus, Cai in view of Peeters further discloses claim 10.f.

l. <u>Claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."</u>

239. Cai discloses claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

240. Cai teaches that "some channels may experience greater variation in the signal-to-noise ratio than others. Thus, in some cases the common margin may be too great, resulting in a bit rate that is unnecessarily slow. In other cases, the common margin may be too small, resulting in a bit rate that is too high which translates into an unnecessarily high bit error rate." *Id.* at 1:56-62.

241. Cai is specifically directed toward a system where SNR margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. This is further evidenced in Figure 2:

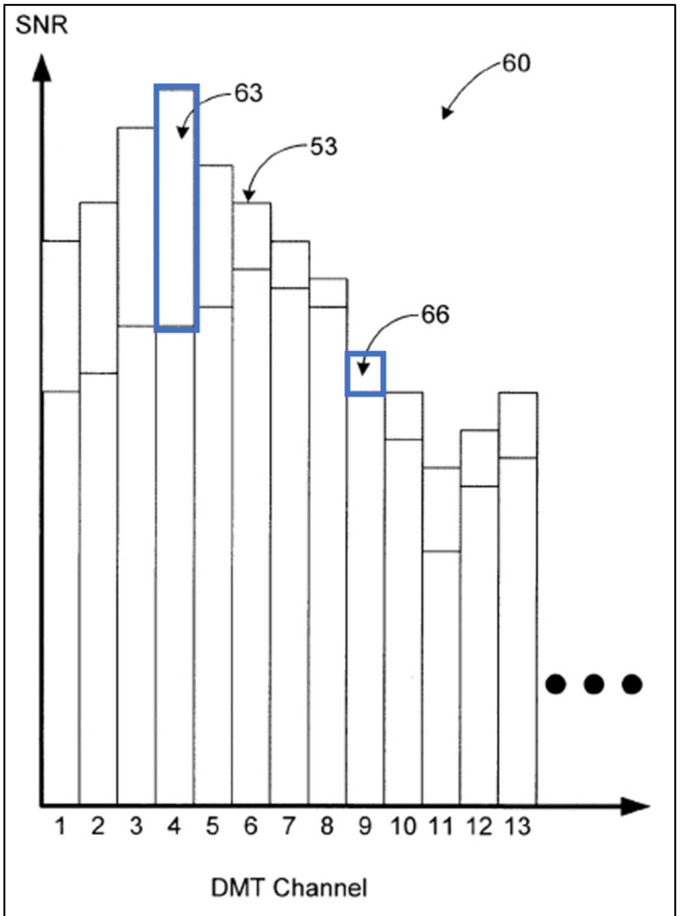


Fig. 2

Id. at Fig. 2 (annotated).

242. As discussed above, Cai discloses a system where a large (or higher) margin is used on one channel, and a small (or lower) margin is used on a different channel. *Id.* at 3:7-13; Fig. 2. A person of ordinary skill in the art would have understood that a channel (or plurality of carriers) which provide a higher margin provides more robust reception than a channel (or plurality of carriers) with a lower SNR margin.

243. Additionally, a person of ordinary skill in the art would have understood that in the system of Cai, any two or more channels can have the first same SNR and two or more of the remaining channels can have the second same SNR.

244. Thus, Cai discloses claim 10.g.

245. As discussed above in § XII.A.1.j, and incorporated herein, Peeters also discloses claim 10.g. Thus, Cai in view of Peeters further discloses claim 10.g.

246. Consequently, claim 10 would have been obvious to a person having ordinary skill in the art in view of Cai and Peeters.

3. U.S. Patent No. 6,516,027 to Kapoor et al. ("Kapoor") in View of Peeters

247. Kapoor in view of Peeters renders obvious each element of claim 10 of the '354 Patent.

a. Brief Description of Kapoor

248. U.S. Patent No. 6,516,027 to Kapoor et al. ("Kapoor") is titled "A Method and Apparatus for Discrete Multitone Communication Bit Allocation," and claims a priority date of February 18, 1999. Kapoor issued on February 4, 2004 from a patent application that was filed on February 18, 1999, and therefore constitutes prior art to the '354 Patent under 35 U.S.C. §102(e).

249. Kapoor discloses "[a] method and apparatus for allocating bits to subchannels in a discrete multitone environment." Kapoor at Abstract. In particular, the method disclosed in the patent "employs the use of precalculated and prestored look-up tables which take into account a desired bit error rate, signal to noise ratio gap for particular coding scheme, and gain scaling factor." *Id.* Kapoor describes techniques to determine "bit allocation values calculated based on different margins, different $P_e/2$[6] error rates, and different coding gains." *Id.* at 8:39-42.

250. As noted above in §IX.A.1 Kapoor, Kapoor was considered by the examiner during the prosecution history. The examiner, however, failed to consider Kapoor in view of

[6] Kapoor defines $P_e/2$ as the "symbol error rate per dimension and uses it interchangeably with the Bit Error Rate (BER)." Kapoor at 5:41-47.

Peeters. As discussed below, claim 10 of the ’354 Patent is rendered obvious by Kapoor in view of Peeters.

b. Brief Description of Peeters

251. I provided a brief description of Peeters above. *See supra*, §XII.A.1.a, which I incorporate by reference here.

c. Motivation to Combine Teachings of Kapoor With Teachings of Peeters

252. A person having ordinary skill in the art would have been motivated to combine the teachings of Kapoor with the teachings of Peeters as recited in claim 10 of the ’354 patent and would have had a reasonable expectation of success in making the combination.

253. Both Kapoor and Peeters are directed to improving the performance of DMT systems. Kapoor’s objective is to provide bit loading (i.e., the allocation of bits to subcarriers) techniques that improve on existing bit loading algorithms. *See, e.g.*, Kapoor at Abstract, 3:7-4:21. Peeters is directed to allocating data elements to sets of carriers. Peeters at 2:3-5. Peeters is used in ADSL applications but can also be implemented in other transmission systems. *Id.* at 7:54-57, 3:47-58, claim 11.

254. The disclosures of Peeters are complementary to those of Kapoor, and it would have been obvious to a person having ordinary skill in the art to combine them. For example, Kapoor states that prior art bit loading algorithms “do not support a bit allocation method which allows different subchannels to operate at different bit error rates or margins,” but that it would be “desirable to have a method which can allocate bits to subchannels based on a desired bit error rate, and further to be able to allow subchannels to operate at different bit error rates.” Kapoor at 4:8-10, 17-21. Kapoor describes that its techniques allow different subchannels to “have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different

coding gains. . . ." *Id.* at 8:39-42. Kapoor thus discloses that different margins can be used on different subchannels. But Kapoor does not describe in detail how to determine what the different margins on the different subchannels should be. Accordingly, a person having ordinary skill in the art would have sought references addressing how to determine what the different margins on different subchannels should be.

255. A person having ordinary skill in the art would thus have been motivated to add the method of Peeters to the communication devices of Kapoor, and would have found it trivial to do so. More specifically, Kapoor describes reducing the measured SNR of each subchannel by the difference between the margin and the coding gain (i.e., by the quantity γ_margin-γ_coding), and then determining the bit allocation and gain scaling values using the resulting reduced measured SNR values. *See, e.g.,* Kapoor at 7:43-10:46. Based on the teachings of Peeters, a person having ordinary skill in the art would have been motivated to use Peeters' method of grouping subsets of carriers together and assigning certain data to the respective subsets of carriers. *See e.g.,* Peeters at 3:16-24. A skilled artisan would have found this modification trivial, particularly because Kapoor discloses that different margins can be used for different subchannels, and Peeters discloses allocating data elements to different sets of carriers.

256. Thus, a person having ordinary skill in the art would have had a strong expectation of success in combining Peeter's teachings (e.g., allocating data elements to different sets of carriers) with Kapoor's bit allocation procedures that allow the noise margin, error probability, and coding gain to vary from subchannel to subchannel.

a. <u>Claim 10</u>

257. Kapoor in view of Peeters discloses each element of claim 10 of the '354 Patent.

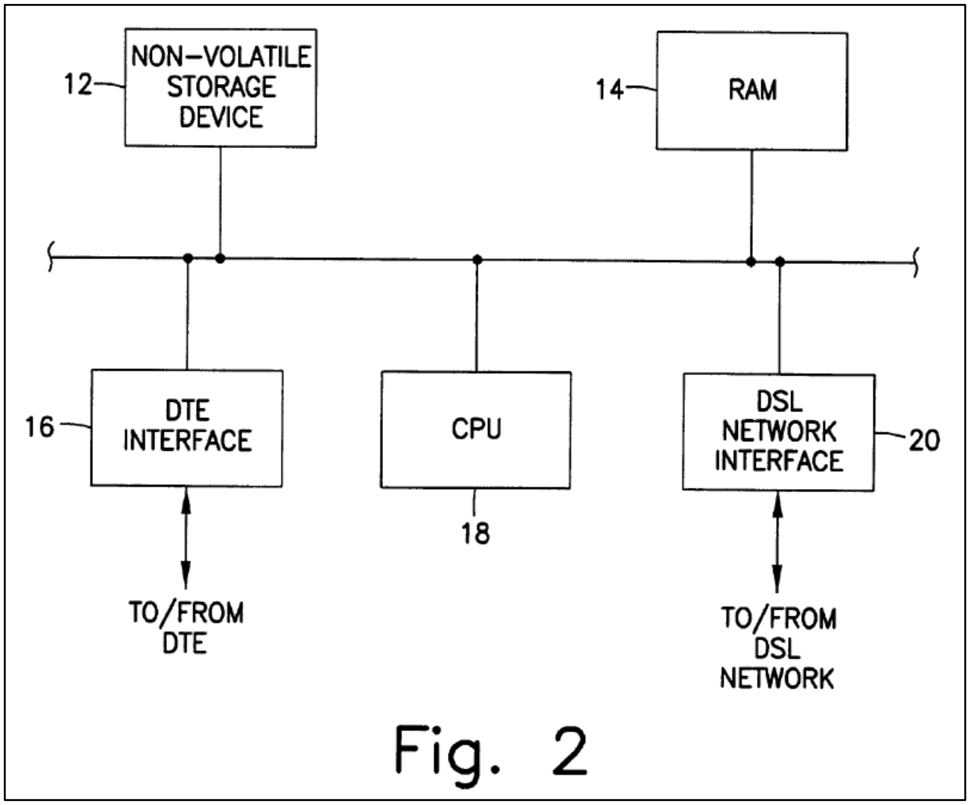
b. <u>Claim 10.pre "A multicarrier communications transceiver operable to:"</u>

258. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Kapoor discloses Claim 10.pre "A multicarrier communications transceiver operable to."

259. Kapoor details a method and apparatus for discrete multitone communication bit allocation. Kapoor at Title. Kapoor relates to a discrete multitone modulation ("DMT") communication system. "The present invention relates to data communications, specifically to an apparatus and method for allocating bits among carrier tone subchannels (bins) in a discrete multitone modulation (DMT) communication system." *Id.* at 1:7-11.

260. Kapoor also discusses SNR gaps that depend on the modulation and coding used in a transmitter. "The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure that the received SNR in the i subchannel corresponds to b_i bits in that Subchannel." *Id.* at 3:58-67.

261. Moreover, the method and apparatus operates over a computer, that connects with a DSL network interface and a DTE interface. "Data terminal equipment interface 16 and DSL network interface 20 are used **to send and receive data to and from data terminal equipment and a DSL network**, respectively." *Id.* at 6:13-16; *Id.* at Figure 2.



Id. at Fig. 2.

262. Thus, Kapoor discloses the preamble of claim 10, to the extent it is limiting.

263. I explained above (*see supra*, § XII.A.1.c), Peeters also discloses the preamble of claim 10, to the extent it is limiting. I incorporate that explanation by reference here.

264. Thus, Kapoor in view of Peeters further discloses claim 10.pre.

c. <u>Claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers"</u>

265. Kapoor discloses claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers."

266. Kapoor discloses receiving a multicarrier symbol. "Subsequent DMT multicarrier modulation equipment made use of digital signal processing techniques including Fast Fourier Transforms and Inverse Fast Fourier Transforms. Digital signal processing allowed a single DMT

communication device to be used to modulate all subchannels, thereby improving reliability and lowering the cost of communications." *Id.* at 2:7-13.

267. Kapoor discloses a plurality of carriers. "A preferred approach is to load each subchannel based on the individual transmission characteristics of that subchannel. Better subchannels, should carry more information than poorer quality subchannels. This allows an efficient use of the communication channel resources." *Id.* at 2:16-20. The indication of multiple subchannels means there are a plurality of carriers. The underlying invention in Kapoor allows for SNR ratios are measured for each plurality of subchannels in a communication system, which is consistent with having a plurality of channels with different SNR ratios as disclosed in the '354 Patent.

268. In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a corresponding plurality of respective bit values, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to noise ratio values also correspond to the plurality of respective bit values. It is another object of the present invention to provide a method of allocating bits to a plurality of transmission subchannels in a communication system, in which a measuring step measures a signal-to-noise ratio for each of the plurality of transmission subchannels. An adjusting step adjusts the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain. *Id.* at 4:32-46.

269. Moreover, different pluralities of carriers are grouped in Kapoor via the different subchannels which each group having different bit allocation values. "Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based

on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:36-42.

270. Kapoor discloses at least two pluralities of carriers in Fig. 5 shown below and its associated text. Specifically, Figure 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

271. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated).

272. Kapoor discloses receiving a multicarrier symbol. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16.

273. Thus, Kapoor discloses claim 10.a.

274. I explained above (*see supra*, § XII.A.1.d), Peeters also discloses claim 10.a. I incorporate that explanation by reference here. Thus, Kapoor in view of Peeters further discloses claim 10.a.

d. Claim 10.b "and a second plurality of carriers"

275. Kapoor discloses claim 10.b "and a second plurality of carriers."

276. Different pluralities of carriers are grouped in Kapoor via the different subchannels which each group having different bit allocation values. "Similarly, the process can be repeated to create a set of tables **for a different SNR gap** for a different line coding technique (step 30). Different subchannels therefore, **can each have bit allocation values calculated based on different margins**, different $P_e/2$ error rates, and different coding gains, **subject to the quantity of tables stored in the communication device 10**." *Id.* at 8:36-42.

277. Kapoor discloses at least two pluralities of carriers in Figure 5 shown below and its associated text. Specifically, Figure 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of **10^{-7} and a bit allocation of 5 bits corresponds** to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of **10^{-8}** of 2.5516e + 02.

Id. at 8:20-24.

278. Thus, Kapoor discloses claim 10.b.

279. I explained above (*see supra*, §XII.A.1.e), Peeters also discloses claim 10.b. I incorporate that explanation by reference here.

280. Thus, Kapoor in view of Peeters further discloses claim 10.b.

e. Claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin;"

281. Kapoor discloses claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin."

282. The Court has construed "SNR margin" as "a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

283. Kapoor meets the Court's definition for SNR Margin. Kapoor describes the "SNR gap" or "margin" as "the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap." Kapoor at 2:21-27.

284. Further, the "SNR gap is a function of a chosen probability of transmission error and the modulation and coding techniques. The SNR gap measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel. The SNR gap is often constant over a wide range of transmission rates which may be transmitted by the particular modulation coding technique. The channel capacity refers to the maximum data rate capable of being transmitted on a particular channel. The

optimum line coding technique has a SNR gap of zero dB. Although such an optimum line code requires infinite decoding/encoding delay and is infinitely complex, it has become practical at typical Digital Subscriber Line (DSL) speeds to implement modulation methods to achieve SNR gaps as low as 1-2 dB. Therefore, one factor to be considered during the bit allocation process is the transmission quality of each subchannel, in order to maximize the bit allocation for each subchannel." *Id.* at 2:21-45.

285. For the SNR required to maintain a specified BER, Kapoor discloses: "the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER)." *Id.* at 3:59-61. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

286. Kapoor further describes how the SNR margin is used in connection with bit allocation:

> The processing unit controls functions which **measure a signal-to-noise ratio** for each of the plurality of transmission subchannels, **adjust the measured signal-to noise ratio** in accordance with an **SNR-margin** and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, **the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values**, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory.

Id. at 5:1-12.

287. These SNR margins have a corresponding bit value as disclosed in Kapoor. "In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a **corresponding plurality of respective bit values**, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling

factor, wherein the signal-to-noise ratio values also correspond to the plurality of respective bit values." *Id.* at 4:32-39.

288. Thus, Kapoor discloses claim 10.c.

289. I explained above (*see supra*, §XII.A.1.f), Peeters also claim 10.c. I incorporate that explanation by reference here.

290. Thus, Kapoor in view of Peeters further discloses claim 10.c.

f. <u>Claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin;"</u>

291. Kapoor discloses claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin."

292. I incorporate by reference my analysis for claim elements 10.pre, 10.a, 10.b, and 10.c.

293. The plurality of subchannels in Kapoor show that the reference discloses that each of the subchannels (carriers) have a separate SNR margin and that each subchannel has a different bit allocation value.

294. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

295. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated).

296. The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission

subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory. *Id.* at 5:1-12.

297. A plurality is construed as meaning more than one, thus, there is a second plurality of bits on a second plurality of carriers which uses a second SNR margin.

298. Thus, Kapoor discloses claim 10.d.

299. I explained above (*see supra*, §XII.A.1.g), Peeters also claim 10.d. I incorporate that explanation by reference here.

300. Thus, Kapoor in view of Peeters further discloses claim 10.d.

g. Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers,"

301. Kapoor discloses Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers."

302. Kapoor discloses that a subset of channels differ from a different subset of channels such that it constitutes different carriers. Although the above description is directed to a bit allocation process in which all subchannels are analyzed and bits allocated, an alternative embodiment exists in which the bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. For example, when the communication device has completed its training sequence and is operating in 'showtime', line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels. "[T]he bit allocation process is completed for a subset of subchannels, with the process not being completed

for the remaining subchannels. . . . line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels." *Id.* at 11:35-42. Here, where the process is completed for a set of subchannels and not for the other set of subchannels, it then follows that there is a difference in the first plurality of carriers versus the second plurality of carriers.

303. Thus, Kapoor discloses claim 10.e.

304. I explained above (*see supra*, § XII.A.1.h), Peeters also discloses claim 10.e. I incorporate that explanation by reference here.

305. Thus, Kapoor in view of Peeters further discloses claim 10.e.

h. Claim 10.f "wherein the first SNR margin is different than the second SNR margin,"

306. Kapoor discloses claim 10.f "wherein the first SNR margin is different than the second SNR margin." I incorporate by reference by analysis for claim element 10.d.

307. "Within this inventive system and method, a framework is provided which also supports the use of different $P_e/2$ rates and SNR margins for different subchannels in a communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55. As stated in Kapoor, different SNR margins can be used for different subchannels.

308. Thus, Kapoor discloses claim 10.f.

309. I explained above (*see supra*, § XII.A.1.i), Peeters also discloses claim 10.f. I incorporate that explanation by reference here.

310. Thus, Kapoor in view of Peeters further discloses claim 10.f.

i. Claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

311. Kapoor discloses claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

312. Kapoor discloses the contrast between SNR margins such that one can determine which is more robust. "Once an SNR_{vec} and SNR_{maxvec} table has been stored for a particular number of bits, the process can be repeated to create a table for a different BER (step 28). Similarly, **the process can be repeated to create a set of tables for a different SNR gap** for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:34-42.

313. Moreover, Kapoor discloses that "because multiple tables corresponding to different $P_e/2$ values can be predetermined and stored, it is possible to allocate bits and establish gain scaling values for different subchannels using different P/2 values for those subchannels. For example, a $P_e/2$ value of 10^{-7} can be used to determine bit allocation and gain scaling for some subchannels, and a $P_e/2$ value of 10^{-8} can be used for the remaining subchannels. Of course, there is no limit to the number of different $P_e/2$ values which can be used, subject only the quantity of SNR tables stored in the communication device." *Id.* at 10:36-46.

314. Thus, Kapoor discloses claim 10.g.

315. I explained above (*see supra*, § XII.A.1.j), Peeters also discloses claim 10.g. I incorporate that explanation by reference here.

316. Thus, Kapoor in view of Peeters further discloses claim 10.g. Consequently, claim 10 would have been obvious to a person having ordinary skill in the art in view of Kapoor and Peeters.

4. Peter Sienpin Chow, *Bandwidth optimized digital transmission techniques for spectrally shaped channels with impulse noise*, STANFORD UNIVERSITY (May 1993) ("Chow")

317. The Chow reference anticipates and/or renders obvious each element of claim 10 of the '354 Patent.

a. Brief Description of Chow

318. *Bandwidth optimized digital transmission techniques for spectrally shaped channels with impulse noise* was published by Peter Sienpin Chow in conjunction with Stanford University in May 1993 ("Chow"). Chow was published in May 1993, and therefore constitutes prior art to the '354 Patent. The Chow reference recognizes that "[i]n order to reliably transmit and receive the highest data rate possible through such non-ideal channels, every components of the communication system needs to be optimized." Chow at Abstract. In particular, the dissertation focuses on optimization of the system transmission bandwidth via use of a multicarrier system using the Discrete Multitone modulation. *Id.*

319. I understand that the Chow reference was publicly available and thus is prior art. *See* Appendix C.

b. Claim 10

320. Claim 10 of the '354 Patent is anticipated and/or rendered obvious by Chow.

c. Claim 10.pre "A multicarrier communications transceiver operable to:"

321. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Chow discloses Claim 10.pre "A multicarrier communications transceiver operable to."

322. Chow applies "a **Discrete Multitone transceiver**, with optimized transmission bandwidth, to these three potential DSL applications." Chow at 78. Chow also discloses "[a] detailed description of the ADSL transmission environment is presented, and results of computer simulation on the performance of a DMT transceiver for ADSL are given." *Id.* at 79. Chow also presents "result of computer simulation on the performance of a DMT transceiver for ADSL." *Id.* at 79.

323. Figure 3.1 of Chow, copied below, is a block diagram of a DMT transmitter, and Figure 3.2, also copied below, is a block diagram of a DMT receiver. Thus, Chow discloses a multicarrier communications transceiver that includes both a transmitter and a receiver.

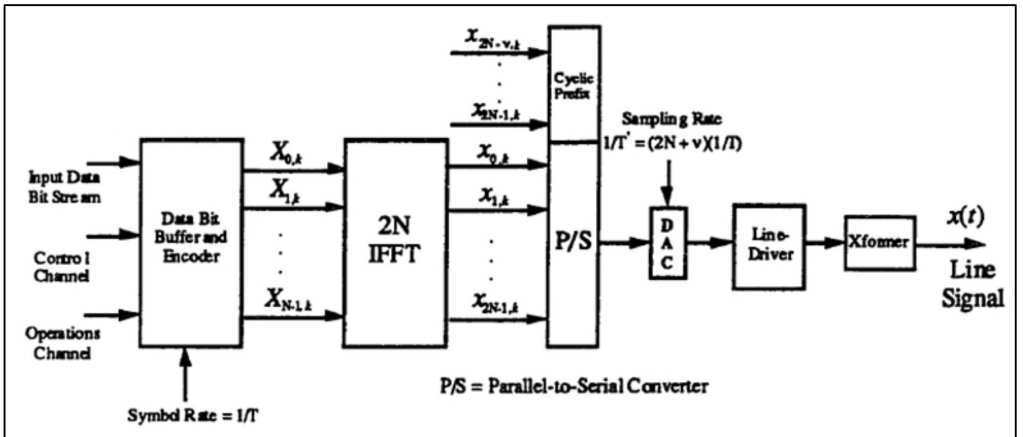


Figure 3.1: The DMT Transmitter

Id. at Fig. 3.1.

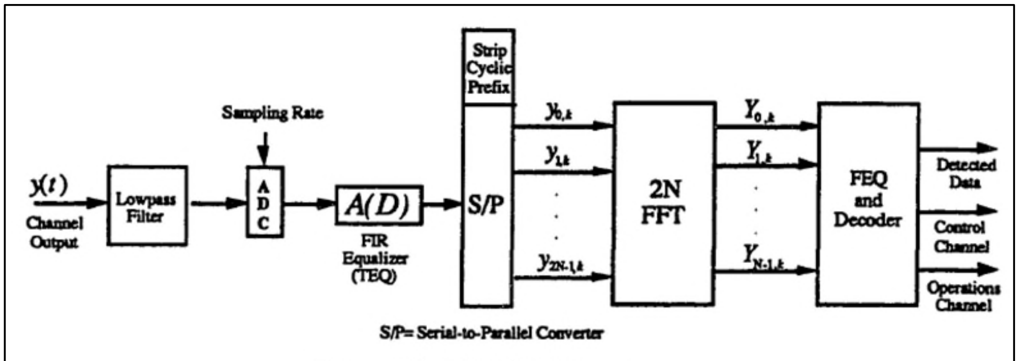


Figure 3.2: The DMT Receiver

Id. at Fig. 3.2

324. Chow also discloses studying a DMT transceiver: "We studied the effect of increasing the transmit power of the DMT transceiver, holding constant the system blocklength at 512 and VHDSL crosstalk coupling at KNEXT = 2×10^{-15} and KFEXT x d = 2.4×10^{-19}. Figure 5.18 shows the achievable throughputs as a function of transmit power for various signaling rates." *Id.* at 107. "Assuming that the crosstalker uses the same signaling strategy and power level as the DMT transceiver, as the transmit power increases the crosstalk noise level increases by the same proportion, and the overall SNR remains constant." *Id.* at 107-08.

325. Chow contains further references use of a DMT system, including an "emphasis . . . on impulse noise mitigation strategies designed specifically for a multicarrier modulation system (in particular, a DMT transceiver for ADSL), we will first briefly review some of the single-carrier, impulse noise mitigation methods that have been proposed in the literature for the sake of completeness." *Id.* at 123-24.

326. Chow also recognizes the benefits of a multicarrier system over a single carrier system. Benefits mentioned include benefits that are specifically contemplated in the '354 Patent, including reduction of interference by distributing over multiple carriers as opposed to a single carrier:

> Fortunately for a multicarrier DMT transceiver, superior impulse noise immunity relative to a single-carrier system is inherent due to its block processing nature. For the ideal case of a true impulse noise occurrence that corrupts only one time domain sample, the total energy of the noise pulse is then spread evenly over every carrier, so in the case of a DMT system implemented with a length 512 FFT, its impulse noise threshold will be approximately 10 log10(512) = 27.1 dB higher than a corresponding single-carrier system. In reality, however, impulse noise occurrences may last for significantly longer than a single sample period at the ADSL sampling rates. As a result, additional protection is necessary to ensure satisfactory system performance. We will now turn our attention to a number of impulse noise mitigation strategies designed specifically for a DMT transceiver. To evaluate the performance of the various impulse noise mitigation strategies discussed in the remainder of this chapter, we make use of the set of canonical loops proposed in [57] for ADSL transceiver evaluation.

Id. at 126.

327. Moreover, Chow recognizes that different carriers of a DMT transceiver can use different margins. "If the DMT transceiver can adaptively learn the spectral shape of the impulse noise and there is sufficient extra margin available, then the extra margin can be placed intelligently on those tones most susceptible to errors due to impulse noise." *Id.* at 151.

328. Chow contemplates the same benefits as disclosed in the '354 Patent, namely the presence of a multicarrier transceiver and how the multicarrier system has increased benefits over a single carrier system:

> In Chapter 6, we examined the characteristics and studied the effects of impulse noise on a DMT system operating over an ADSL transmission environment. We proposed a number of impulse noise mitigation strategies designed specifically for a DMT transceiver that exploit both time and frequency domain characteristics of impulse noise and provide side information to the decoder for erasure declarations. Furthermore, we presented a soft decision, multicarrier, error control technique that continuously adapts both the transmitter and the receiver during normal system operation and adjusts the target system performance margin on a subchannel-by-subchannel basis. Lastly, we tested our proposed impulse noise mitigation schemes through computer simulation and found them to be quite effective in reducing the damage of impulse noise.

Id. at 164-65.

329. Thus, it is my opinion that Chow discloses and/or renders obvious the preamble of claim 10, to the extent it is limiting.

d. <u>Claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers"</u>

330. Chow discloses and/or renders obvious that the multicarrier communications transceiver is operable to receive a multicarrier symbol comprising a first plurality of carriers.

331. Figure 1.1 of Chow, copied below, is a block diagram of a digital communication system that uses multicarrier modulation and includes a receiver that is operable to receive a multicarrier symbol.

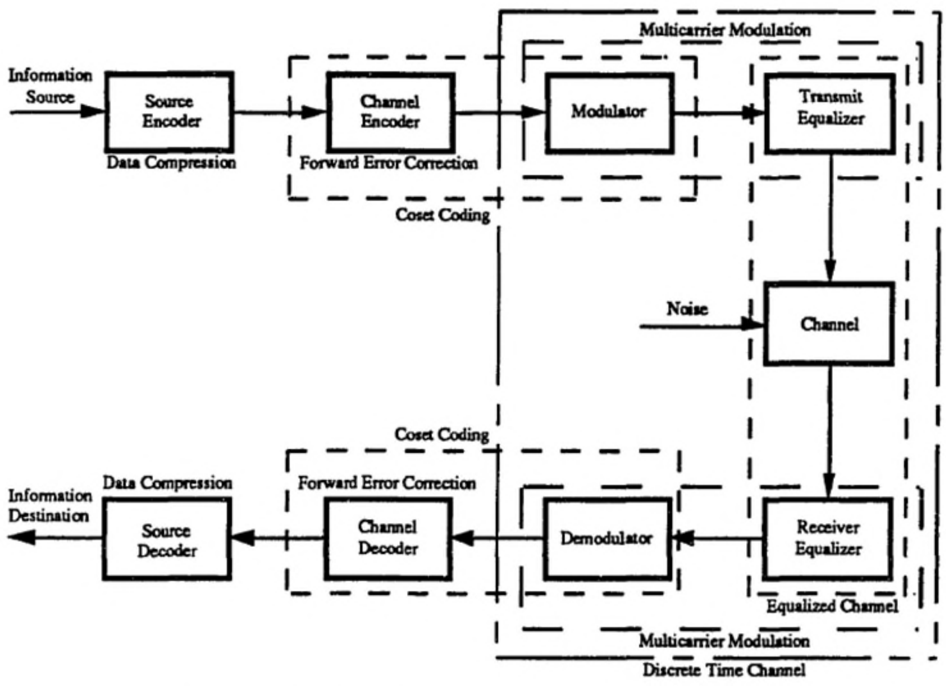


Figure 1.1: Digital Communication System Model

Id. at Fig. 1.1.

332. Figure 3.2 of Chow, copied below, is a block diagram of a DMT receiver.

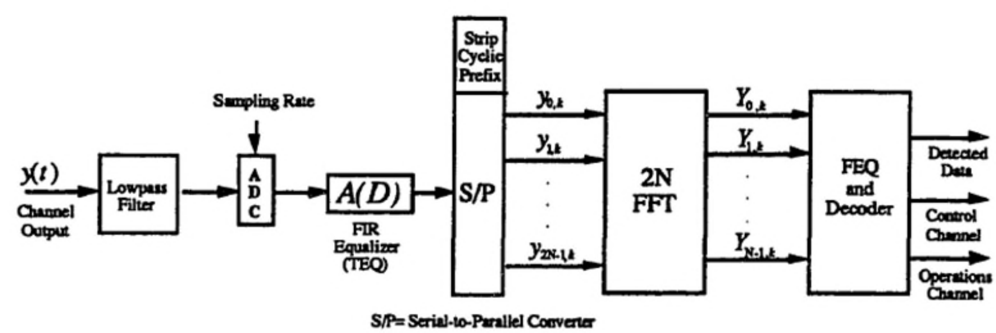


Figure 3.2: The DMT Receiver

Id. at Fig. 3.2

333. Chow discloses that a "DMT modulator divides the data transmission channel into a fixed number of, say *N*, parallel, complex, independent subchannels in the frequency domain as shown in Figure 2.5." *Id.* at 19.

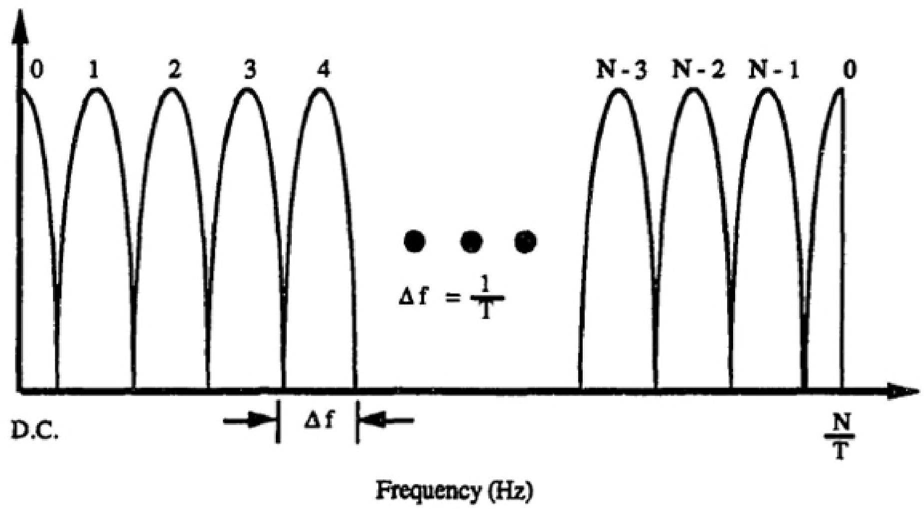


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5

334. Chow further discloses that:

> Each of the "tones", or subchannels, is $\Delta f = \frac{1}{T}$ wide in the frequency domain, where T is the (block) multicarrier symbol period, and if N is sufficiently large, the channel power spectral density curve will be virtually flat within each of the subchannels.

Id. at 19-20.

335. Accordingly, Chow discloses a multicarrier symbol that includes subchannels, and a receiver, in a transceiver, that is operable to receive the multicarrier symbol.

336. Chow also discloses that each of the subchannels in a multicarrier symbol has its own carrier: "The fundamental goal of all 'multicarrier' modulation techniques is to partition a data transmission channel with ISI into a set of orthogonal, memoryless subchannels, each with its own 'carrier'. (*See* [23] and [24]). Data is transmitted through each subchannel independently of other subchannels, and within each subchannel, the channel response is (ideally) flat, as long as the channel is partitioned sufficiently." *Id.* at 16-17.

337. Chow discloses that the multicarrier symbol comprises a first plurality of carriers because it discloses that each DMT symbol has multiple subchannels, the number of which Chow denotes as *N*. For example, Chow describes a DMT system that is used for simulation of ADSL, and that ADSL system has *N* = 256 subchannels. *Id.* at 86; *see also id.* at 66, 68, 106. As Chow discloses (*see, e.g.*, *id.* at 16-17), and as would have been appreciated by a person having ordinary skill in the art even absent the disclosures of Chow, each of these 256 subchannels is associated with its own carrier. Accordingly, within each DMT symbol are many pluralities of carriers, including a first plurality of carriers.

338. To illustrate, I have copied below an annotated version of Figure 2.5 of Chow, in which I have indicated the subchannels corresponding to one possible first plurality of carriers:

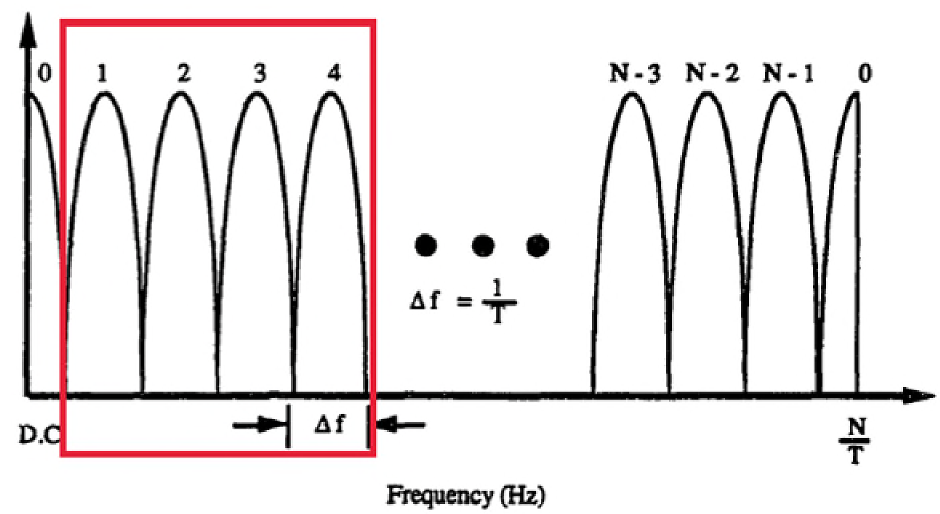


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5 (annotated).

339. As would have been appreciated by a person having ordinary skill in the art, there are many other pluralities of carriers in the multicarrier symbols disclosed by Chow. Specifically, any two or more carriers make up a first plurality of carriers.

340. As explained further below, Figures 6.20 through 6.27 of Chow also show various pluralities of carriers, including a first plurality of carriers.

341. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.a.

e. <u>Claim 10.b "and a second plurality of carriers"</u>

342. Chow discloses and/or renders obvious claim 10.b "and a second plurality of carriers."

343. I incorporate by reference my analysis for claim 10.a.

344. As I explained for claim 10.a, Chow describes a DMT system that has 256 subchannels, each of which is associated with its own carrier, and there are many pluralities of carriers within each DMT symbol, including both a first plurality of carriers and a second plurality of carriers. To illustrate, I have copied below a version of Figure 2.5 of Chow in which I have indicated the subchannels corresponding to two possible pluralities of carriers, one plurality in red and the other in blue:

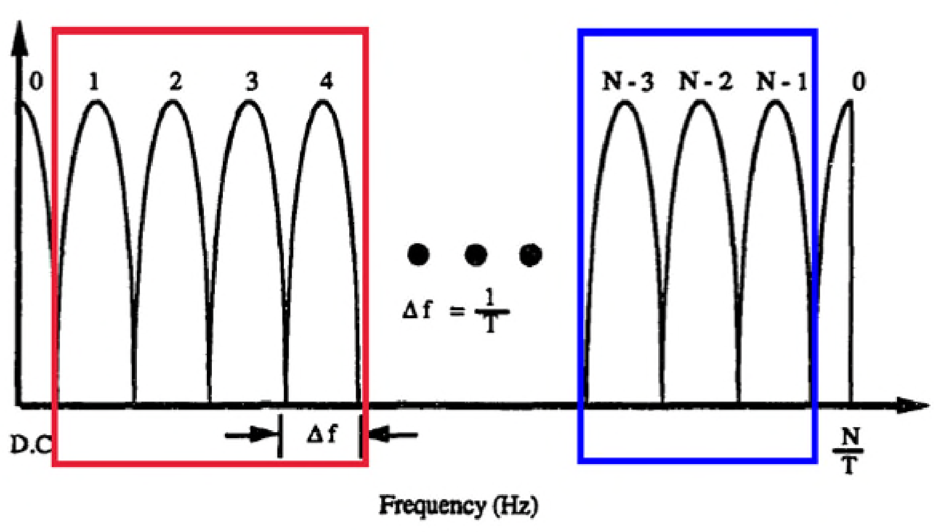


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5 (annotated).

345. As would have been appreciated by a person having ordinary skill in the art, there are many other first and second pluralities of carriers in the multicarrier symbols disclosed by Chow. Specifically, any two or more carriers make up a first plurality of carriers, and any two or more carriers make up a second plurality of carriers. As shown in the annotated version of Figure 2.5 above, the subsets of two or more carriers can be disjoint so there is no overlap in the carriers of the first plurality and the carriers of the second plurality.

346. I note that the carriers in the first plurality need not be adjacent to each other, nor do the carriers in the second plurality need to be adjacent. As a result, the first plurality of carriers could include, for example, carrier 1 and carrier 3, or carrier 2 and carrier N-3, or any two or more of the carriers available. Likewise, the second plurality of carriers can include any two or more carriers, regardless of whether they are adjacent.

347. As explained further below, Figures 6.20 through 6.27 of Chow also illustrate multiple pluralities of carriers, including a first plurality of carriers and a second plurality of carriers.

348. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.b.

f. <u>Claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin;"</u>

349. Chow discloses and/or renders obvious claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin."

350. Chow discloses "2.2 SNR Gap and the Gap Approximation" which includes "System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement." *Id.* at 13.

351. Chow explicitly discloses that SNR margins are used to transport data. "[I]n the case of maximizing total data throughput at a fixed margin lower than the maximum achievable

margin, some of the worst subchannels used may not have the necessary SNR to transport any data at the maximum achievable margin." *Id.* at 59.

352. Moreover, Chow discloses assigning pluralities of bits to carriers, which means pluralities of bits are received on carriers using SNR margins.

353. Chow discloses a DMT system that uses 256 subchannels, each of which always carries a plurality of bits whenever it carries any bits. *See e.g., id.* at 68 (N=256, b_{min}=2). Thus, any plurality of carriers that carries bits always carries a plurality of bits.

> "Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution."

Id. at 69-70.

354. Chow provides many plots illustrating pluralities of bits assigned to carriers, and the use of different SNR margins on different pluralities of those carriers.

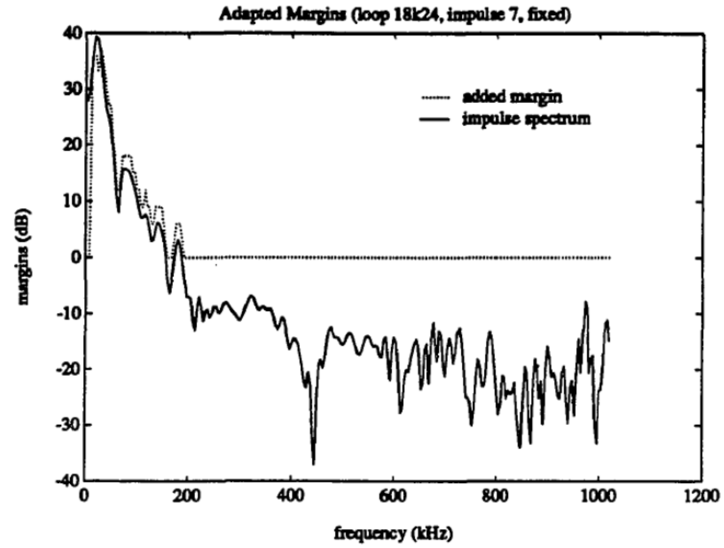


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20.

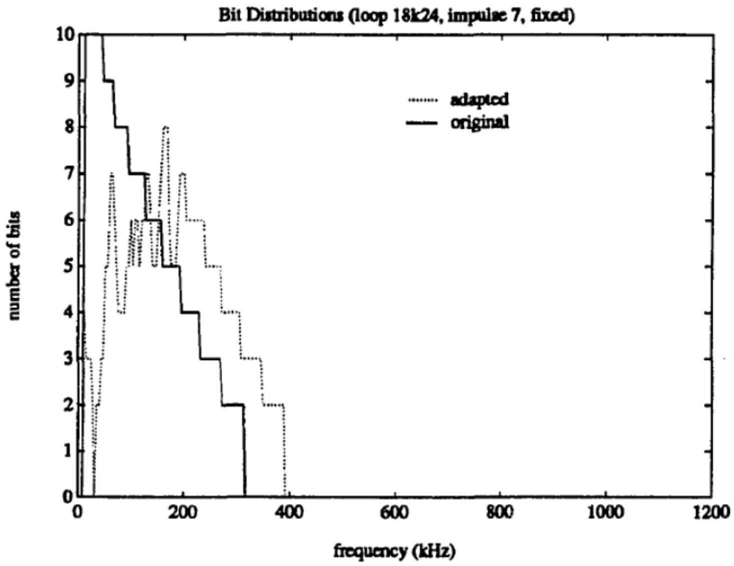


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at 6.21.

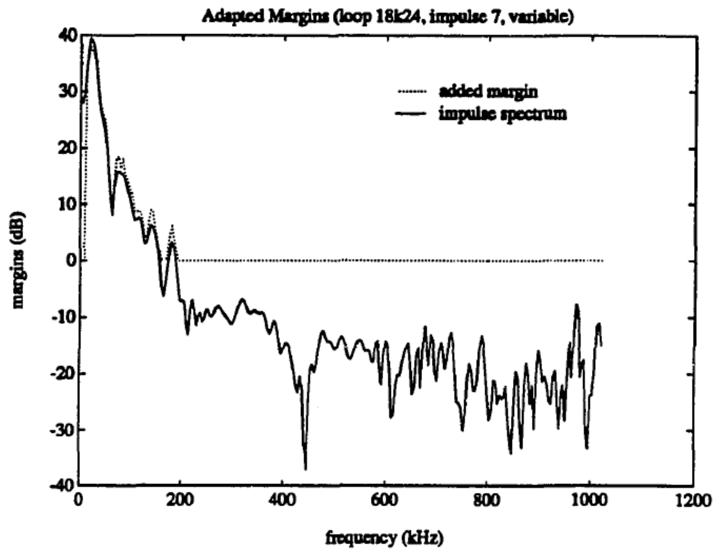


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

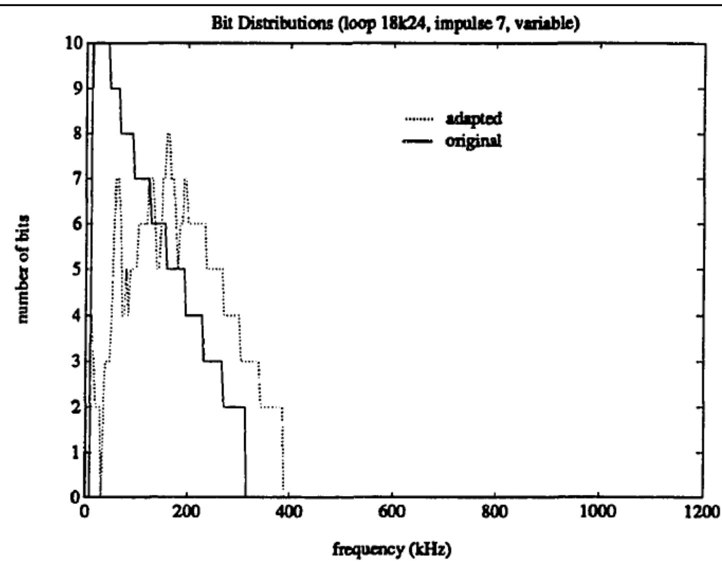


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Fig. 6.23.

"Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of

additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones."

Id. at 158-60.

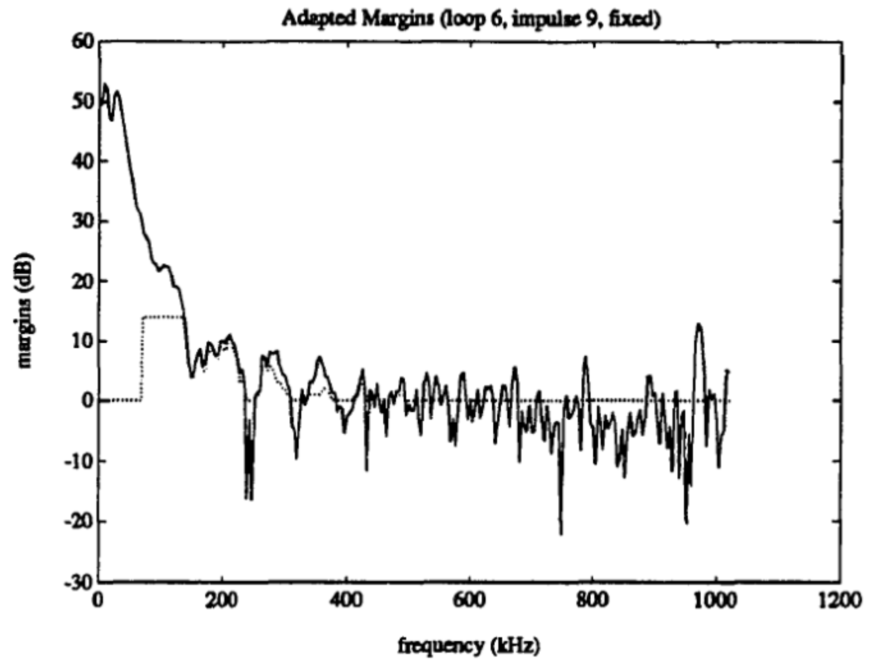


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

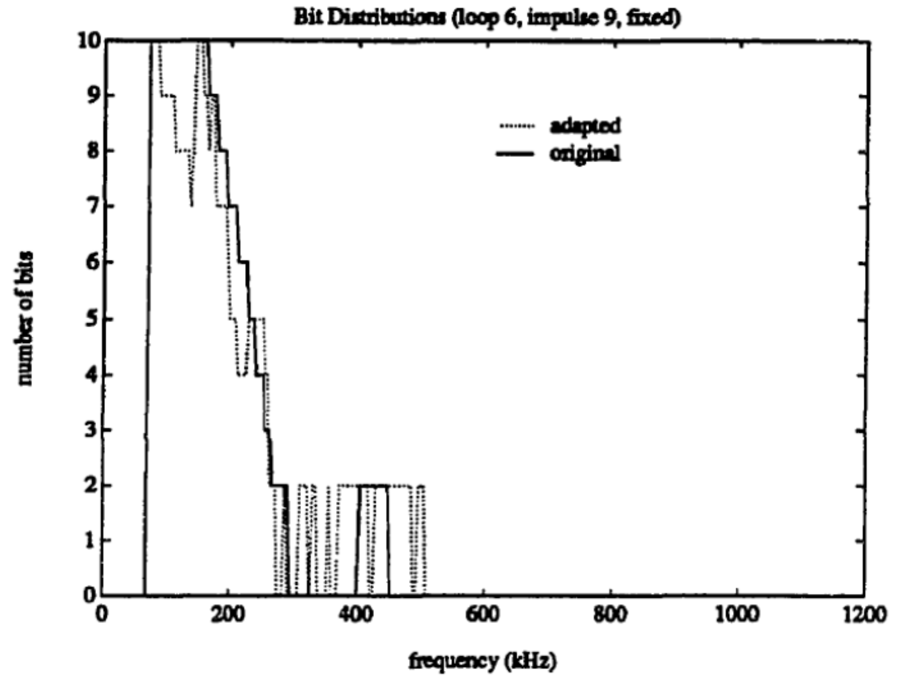


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25.

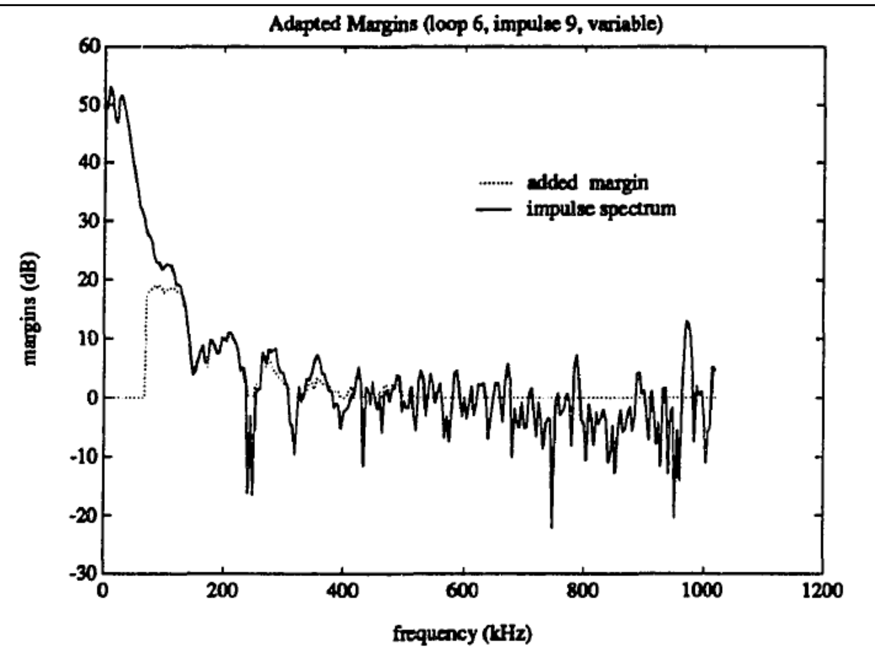


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26

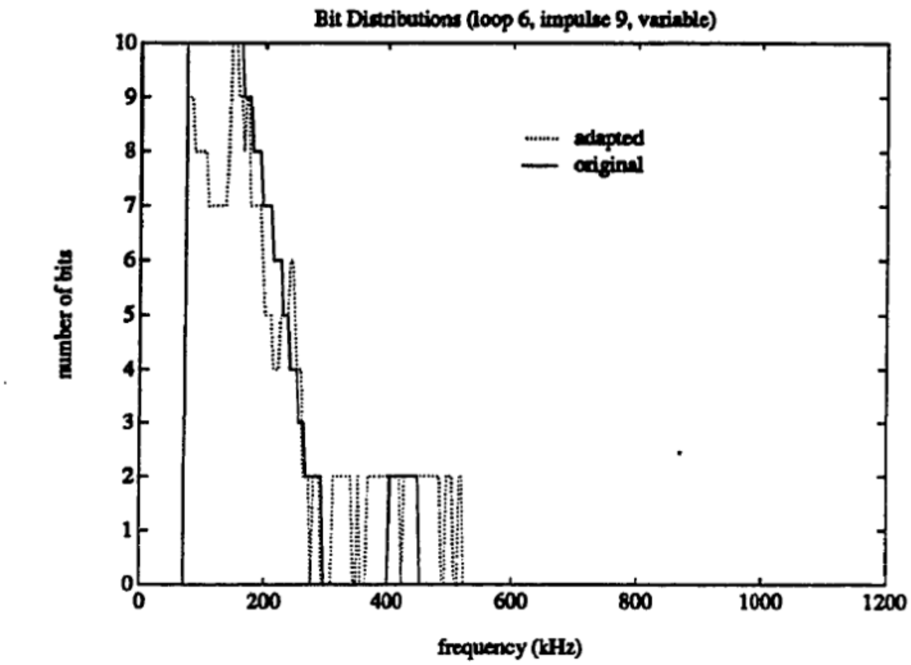


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27.

355. As one of many examples, I have provided below annotated versions of Figures 6.20 (margins) and 6.21 (bit distribution) showing one possible first plurality of bits on the first plurality of carriers using a first SNR margin of approximately 18 dB.

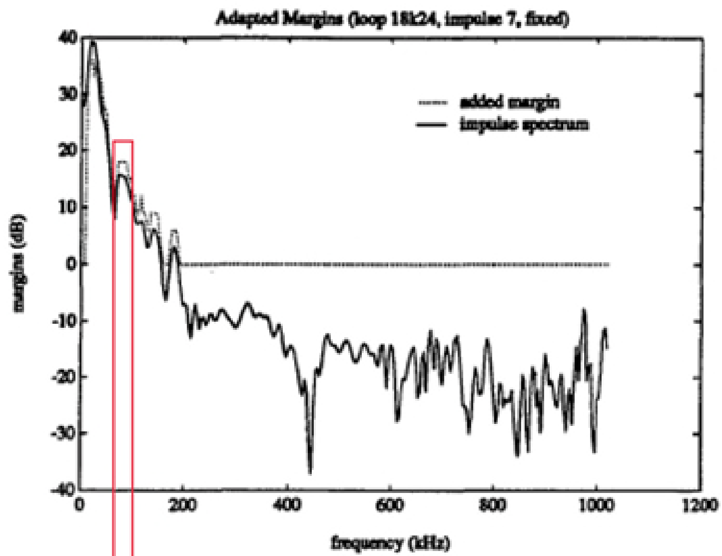


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

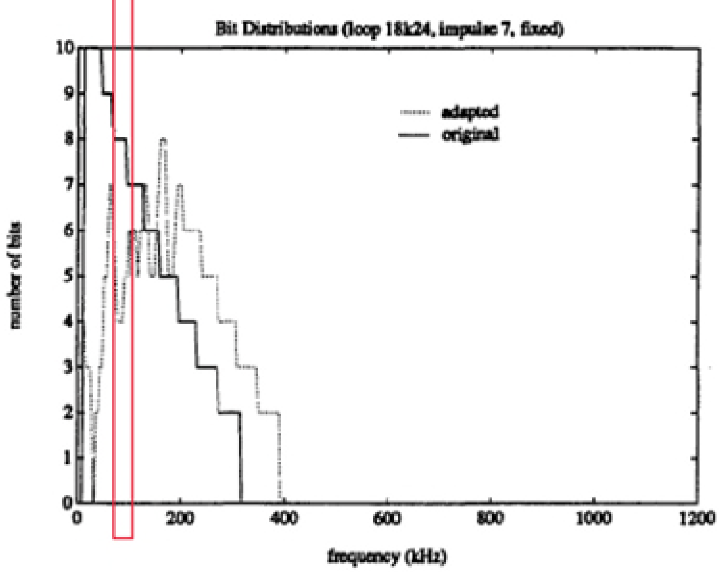


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Figs. 6.20 and 6.21 (annotated).

356. As another example, I have provided below annotated versions of Figures 6.24 (margins) and 6.25 (bit distribution) showing another possible first plurality of bits on the first plurality of carriers (*i.e.*, those between roughly 50 kHz and 150 kHz) using a first SNR margin of approximately 14 dB.

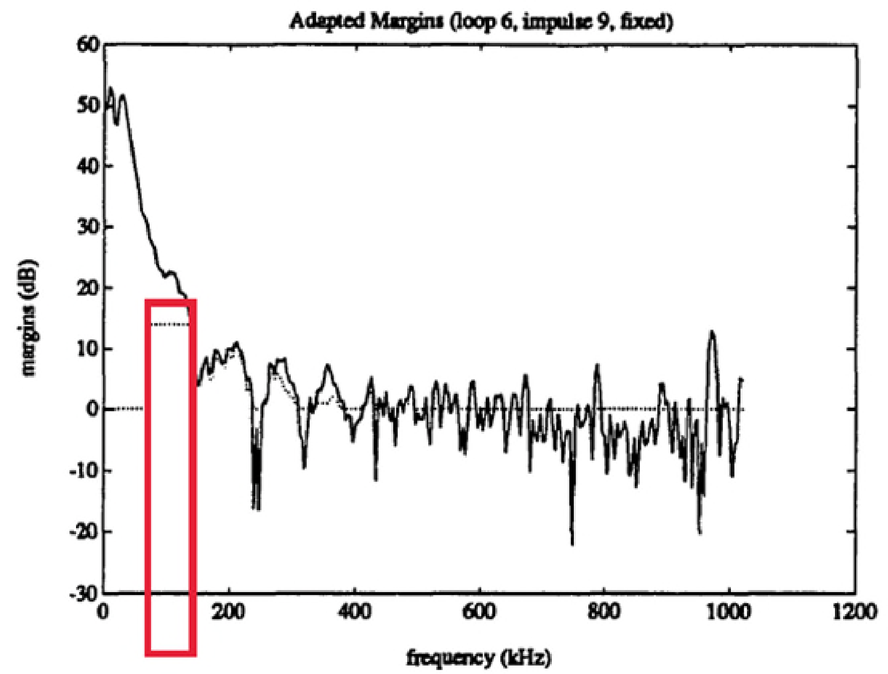


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24 (annotated).

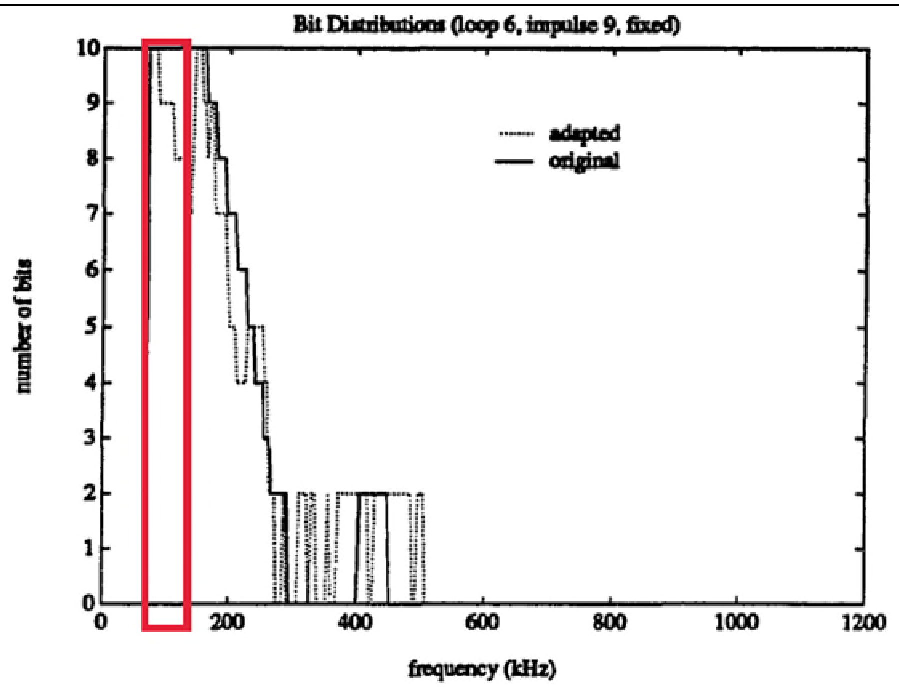


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25 (annotated).

357. Although I have indicated regions of the plots corresponding to more than two carriers, as few as two carriers can be included to comprise the first plurality of carriers. Again, Chow discloses many possible first pluralities of bits on many possible first pluralities of carriers using a first SNR margin, as illustrated in, for example, Figures 6.20 through 6.27 and described in Chapter 6 of Chow.

358. To the extent it is determined that Chow does not sufficiently disclose that the multicarrier communications transceiver is operable to receive a first plurality of bits on the first plurality of carriers using a first SNR margin, using the same first SNR margin on multiple carriers would have been obvious to a person having ordinary skill in the art. For example, it would have been obvious to a person having ordinary skill in the art to round the added margin amounts to integer numbers of dB or to the nearest tenth of a dB in order to reduce transceiver complexity, given that one goal of Chow's work is to manage and limit complexity. *See, e.g.*, *Id.* at 1 ("The goal of our present work is to facilitate the design of a practical communication system that will approach this theoretically optimal performance with a level of implementational complexity that can be realized with today's technology."). As a result of such rounding, the multicarrier communications transceiver would be operable to receive a first plurality of bits on the first plurality of carriers using a first SNR margin.

359. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.c.

g. <u>Claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin;"</u>

360. Chow discloses and/or renders obvious claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin."

361. Among other things, Chow investigates techniques for improving the performance of DMT systems in the presence of impulse noise. *Id.* at 114-15. Chow notes that most practical communication systems are designed "with a built-in performance margin to take the detrimental effects of impulse noise into account." *Id.* at 114. Chow teaches that the use of different margins on different subchannels can improve robustness in the presence of impulse noise. Specifically, Chow discloses that "[i]f the DMT transceiver can adaptively learn the spectral shape of the impulse noise and there is sufficient extra margin available, then the extra margin can be placed intelligently on those tones most susceptible to errors due to impulse noise." *Id.* at 114, 151. Thus, Chow teaches that the performance of a DMT system can be improved by detecting whether a subchannel is suffering from impulse noise and, if it is, allocating excess margin to that subchannel. As would have been recognized by a person having ordinary skill in the art, the result of this allocation would be that different subchannels would have different margins (e.g., some subchannels would have the "base" margin and others would have the base margin plus added margin)..

362. Chow teaches monitoring "the occurrence of a large number of unusually high error signals over the carriers in a DMT symbol" and using a threshold to decide whether "the error signal on a particular subchannel is 'unusually high.'" *Id.* at 151. When more than a threshold number of subchannels have been found to have unusually high error signals, Chow teaches that an impulse is likely to be present. *Id.* In response, "the estimate of the impulse spectrum is updated, using the mean squared error signals on all of the subchannels." *Id.* at 151-52. Chow defines a running sum, α_{ij}, which is the impulse spectral estimate on subchannel i at time j. *Id.* at 152. Chow also defines another threshold, *impthresh*, and teaches that after some number of suspected impulse occurrences, "additional margin will be given to those subchannels

with mean squared error estimates, α_{ij}," that exceed *impthresh*. *Id.* Chow explains in detail how to determine how much additional margin to allocate to each subchannel whose mean squared error estimate, α_{ij}, exceeds *impthresh*, and Chow presents the results of multiple simulations illustrating the effect of the disclosed techniques. *See id.* at 152-61.

363. Chow discloses a DMT system that uses 256 subchannels, each of which always carries a plurality of bits whenever it carries any bits. *See e.g.*, *id.* at 68 (N=256, b_{min}=2). Thus, any plurality of carriers that carries bits always carries a plurality of bits.

364. Figures 6.20 through 6.27 of Chow illustrate many possible second pluralities of bits on second pluralities of carrier using a second SNR margin. In the annotated versions below, I have indicated in blue the locations of several possible second pluralities of carriers and second pluralities of bits on the second pluralities of carriers. . Although I have indicated regions of the plots corresponding to more than two carriers, as few as two carriers can be included in the second plurality of carriers.

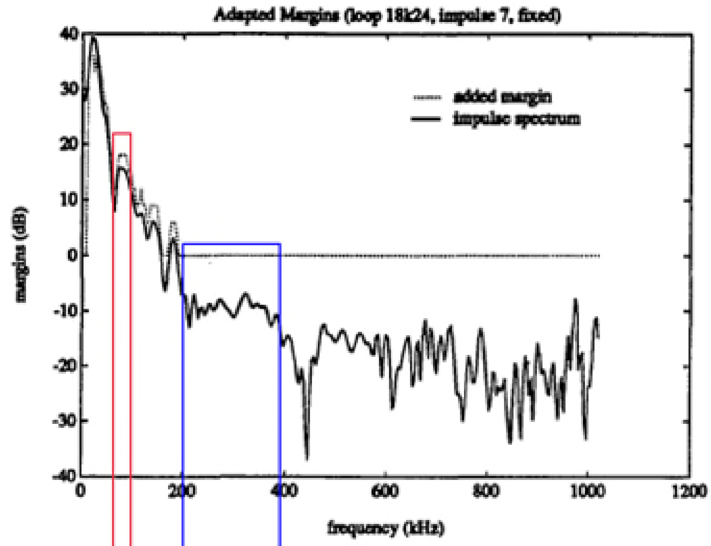


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

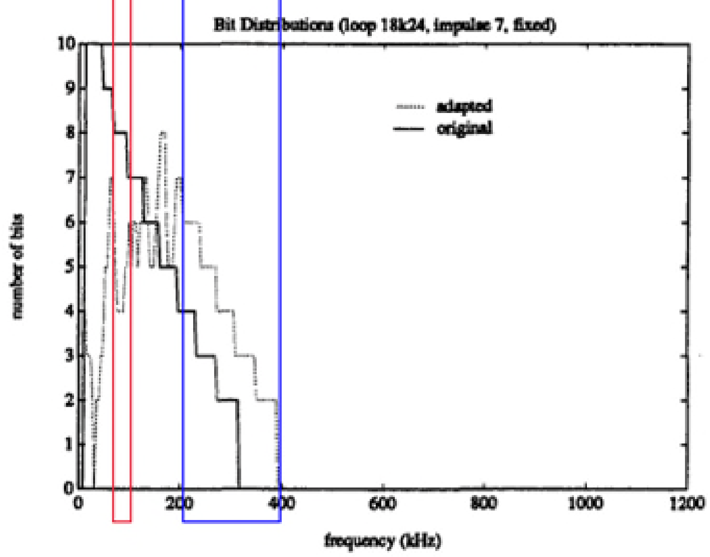


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Figs. 6.20, 6.21 (annotated).

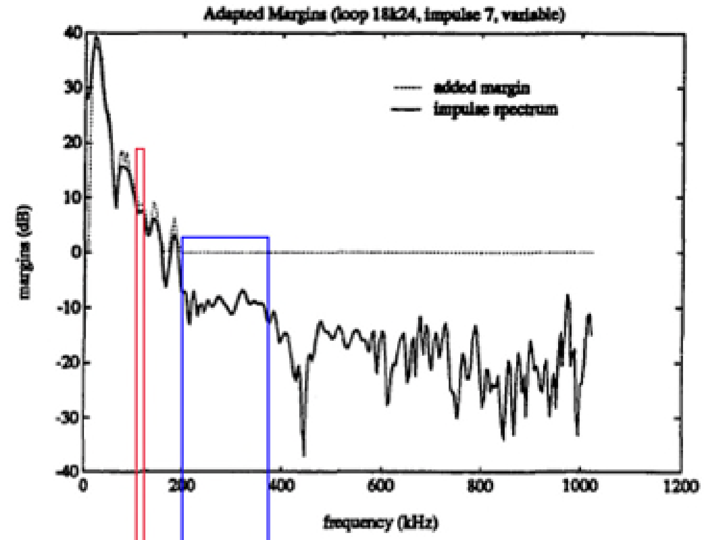


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

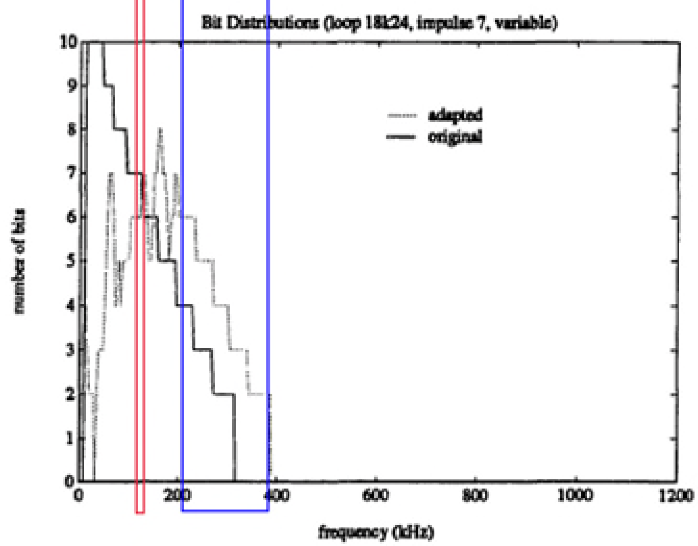


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Figs. 6.22, 6.23 (annotated).

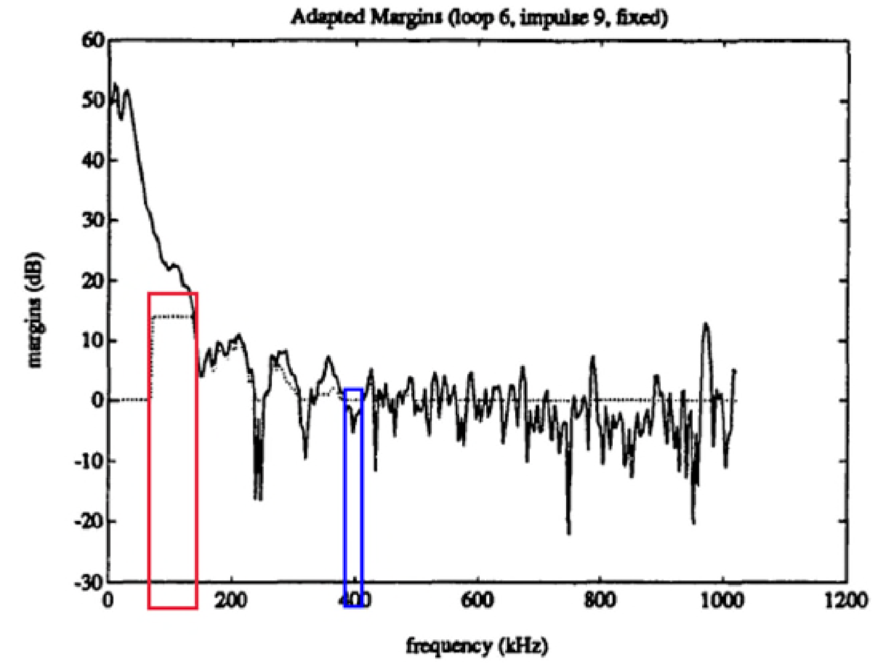


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at. Fig. 6.24 (annotated).

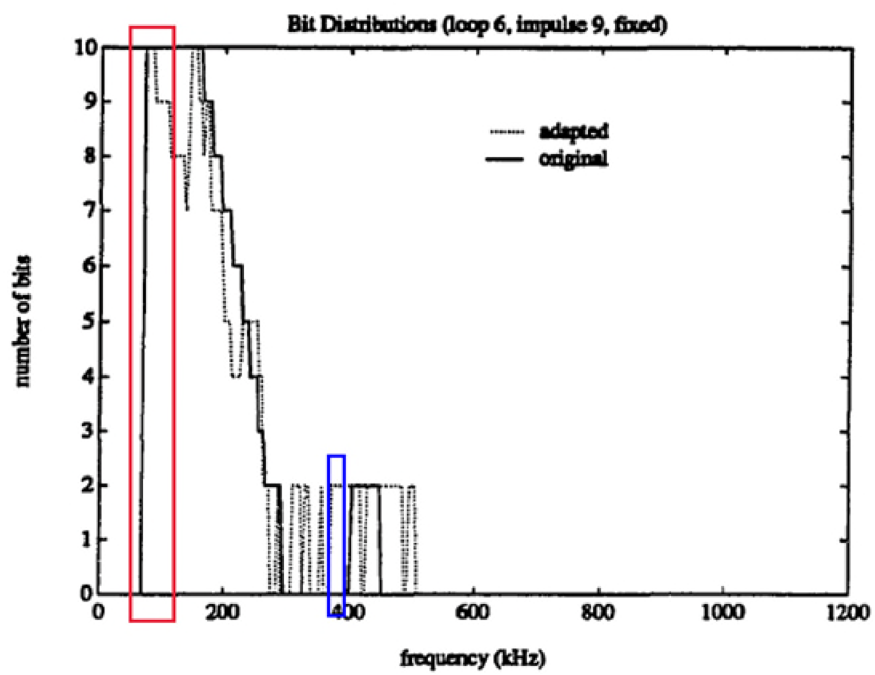


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25 (annotated).

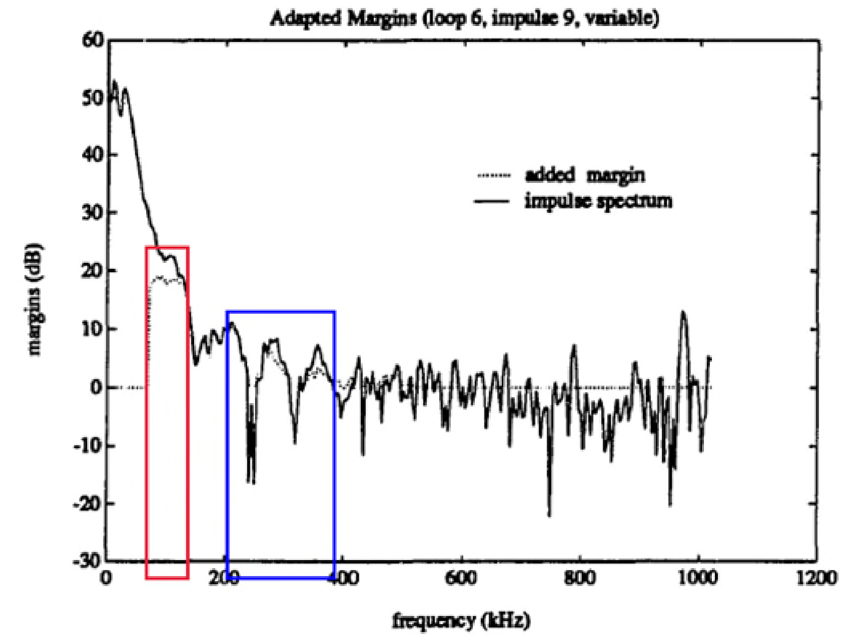


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26 (annotated).

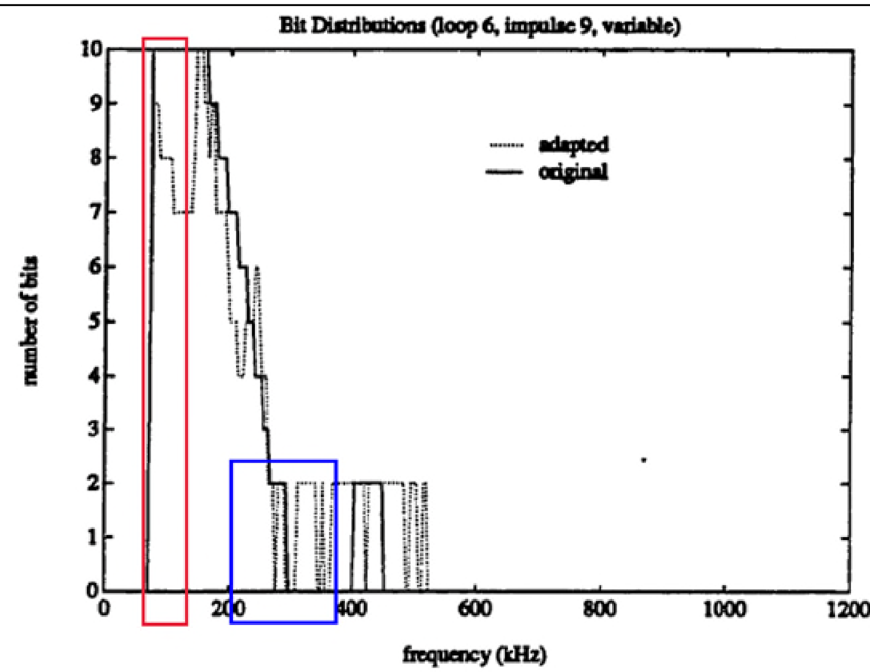


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27 (annotated).

365. Chow details how there can be a delineation of a first carrier and a second carrier such that there can be a second plurality of bits on a second carrier using a second SNR margin. "The performance of this frequency domain clipping technique in general depends on the manner in which power is allocated among the carriers, the channel transfer function, and the actual number of carriers used." *Id.* at 143. In particular "This figure [6.21] clearly demonstrates the ability of a DMT system to move bits from the lower carriers to the higher carriers in order to avoid the large low frequency content of the injected impulse noise. In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

> Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution.

Id. at 69-70.

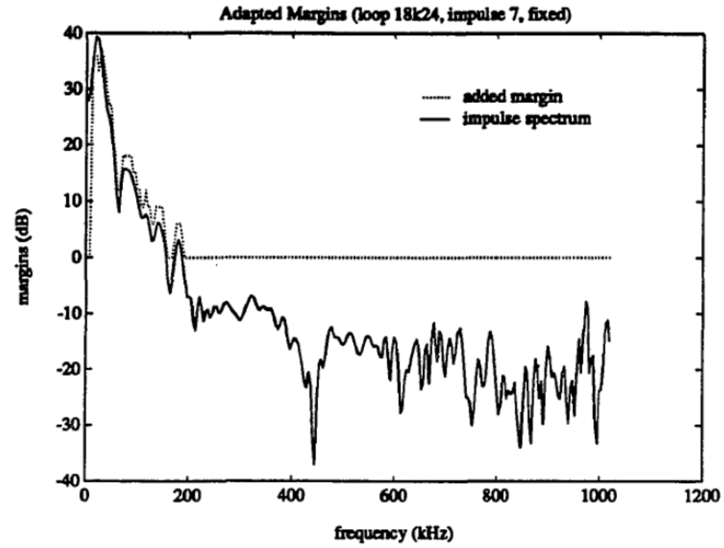


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20.

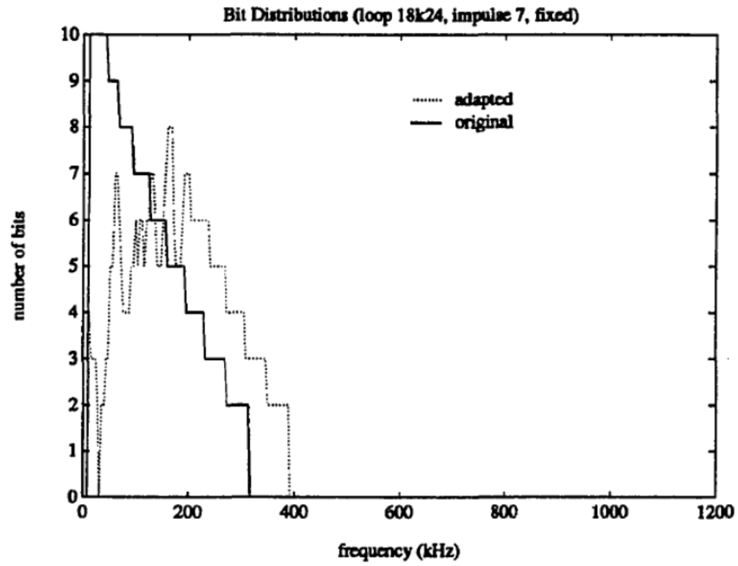


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Fig. 6.21.

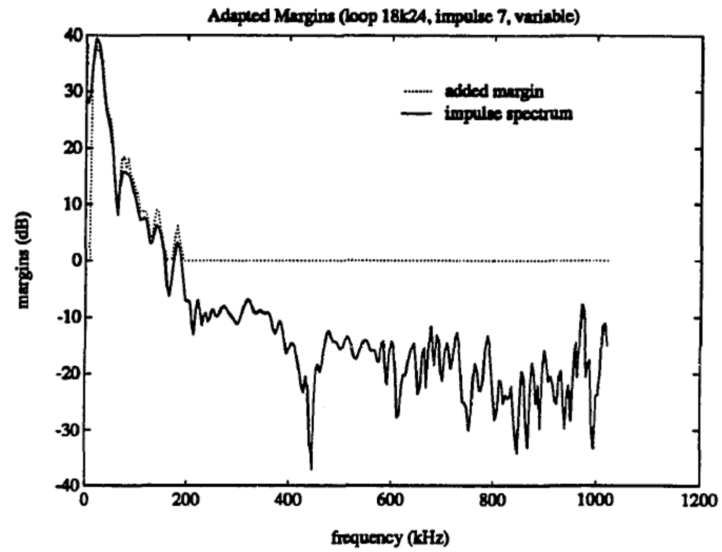


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

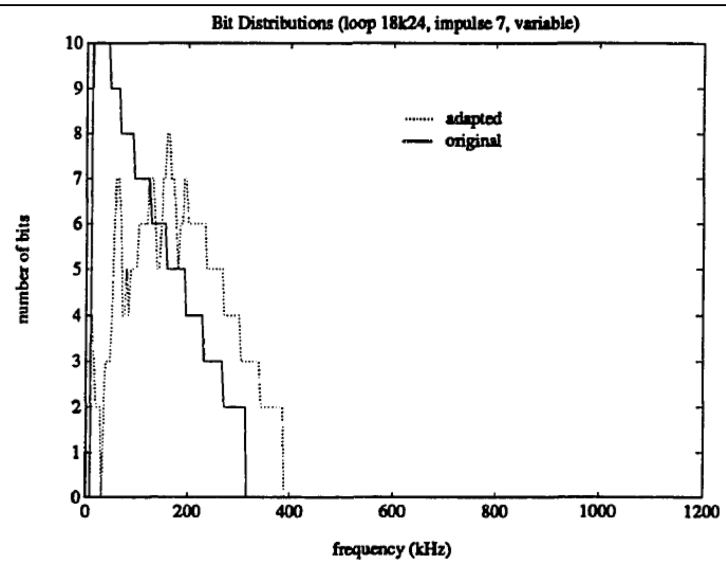


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Fig. 6.23.

366. "Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased

margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones." *Id.* at 158-60.

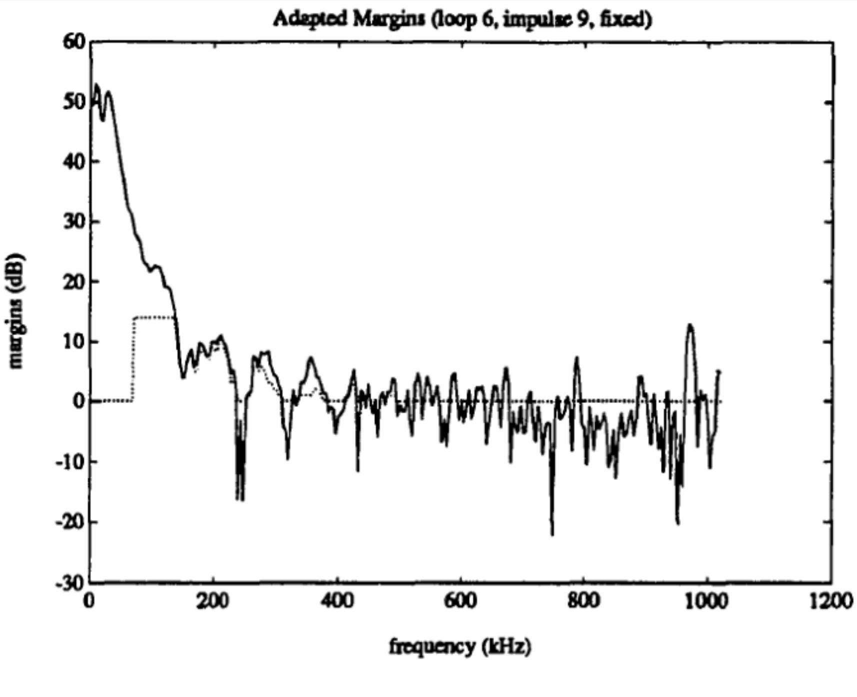


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

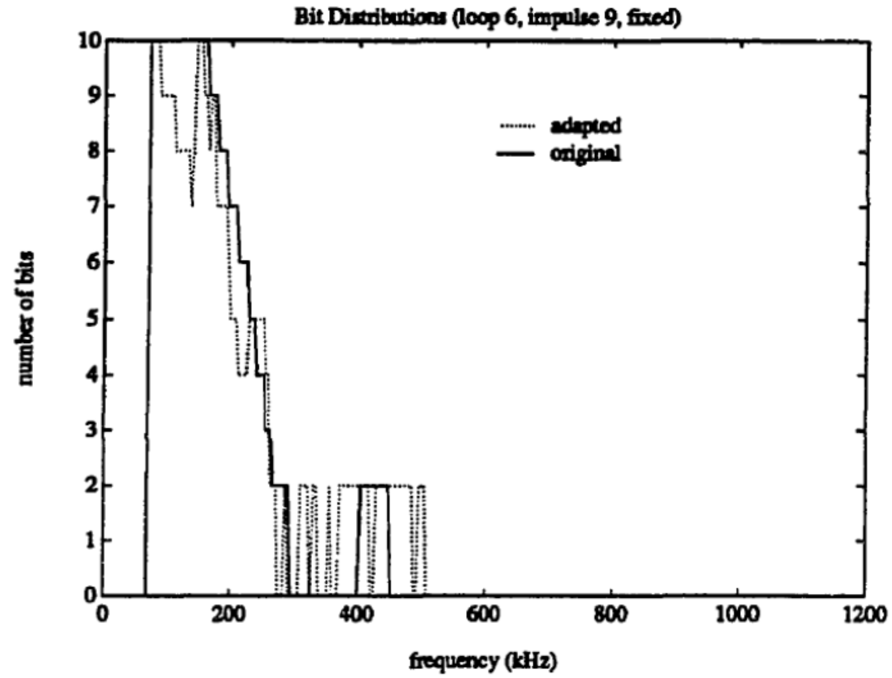


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25.

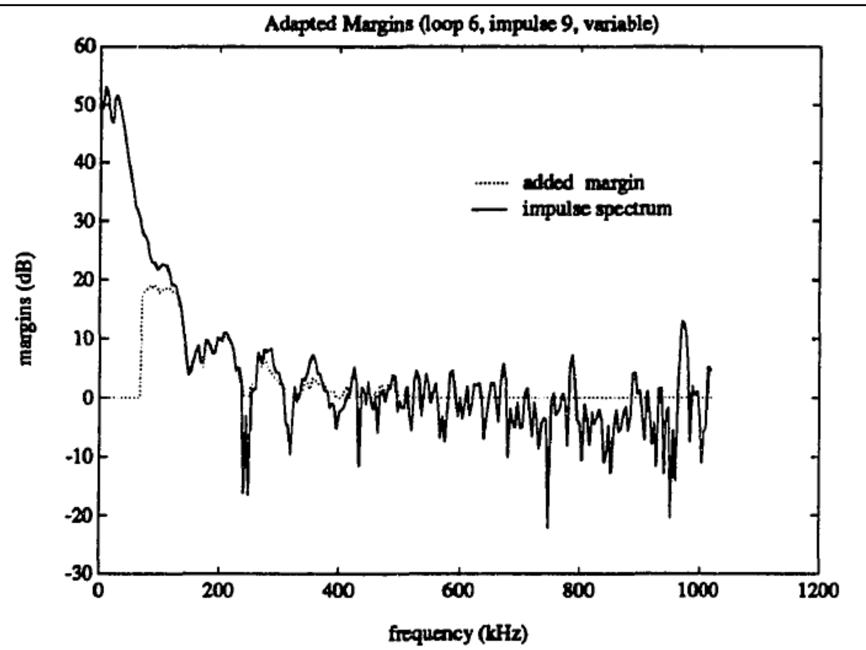


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26

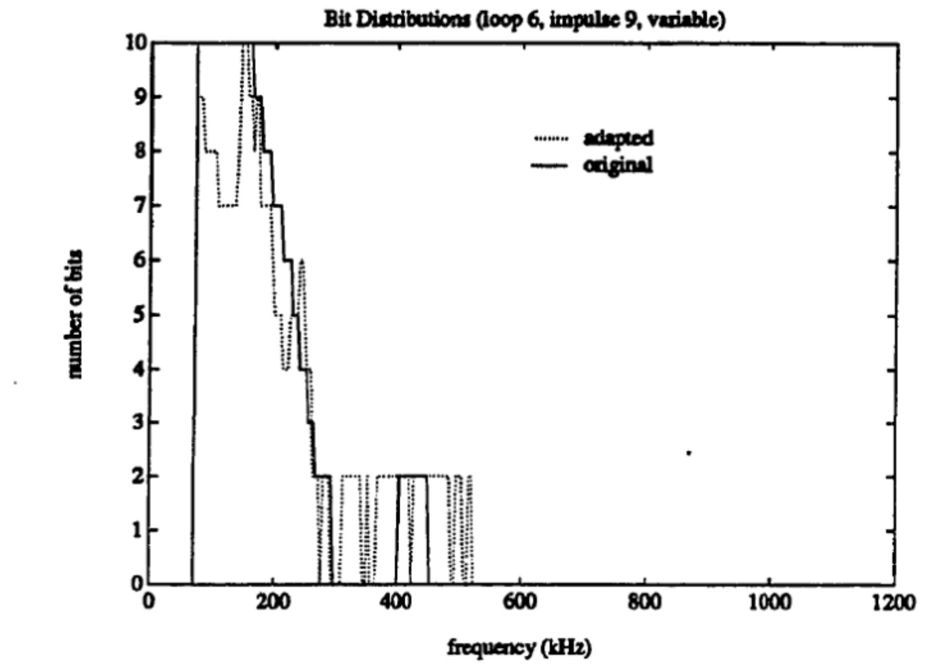


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27.

367. To the extent it is determined that Chow does not sufficiently disclose that the multicarrier communications transceiver is operable to receive a second plurality of bits on the second plurality of carriers using a second SNR margin, using the same second margin on multiple carriers would have been obvious to a person having ordinary skill in the art. For example, it would have been obvious to a person having ordinary skill in the art to round the added margin amounts to integer numbers of dB or to the nearest tenth of a dB in order to reduce transceiver complexity, given that one goal of Chow's work is to manage and limit complexity. *See, e.g.*, *id.* at 1 ("The goal of our present work is to facilitate the design of a practical communication system that will approach this theoretically optimal performance with a level of implementational complexity that can be realized with today's technology."). As a result of such rounding, the multicarrier communications transceiver would operable to receive a second plurality of bits on the second plurality of carriers using a second SNR margin.

368. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.d.

h. <u>Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers,"</u>

369. Chow discloses and/or renders obvious claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers."

370. As I explained for claim 10.a and claim 10.b, Chow describes a DMT system that has 256 subchannels, each of which is associated with its own carrier, and there are many pluralities of carriers within each DMT symbol, including both a first plurality of carriers and a second plurality of carriers. To illustrate, I have copied below a version of Figure 2.5 of Chow in which I have indicated the subchannels corresponding to two possible pluralities of carriers, one plurality in red and the other in blue, wherein the first plurality of carriers is different than the second plurality of carriers:

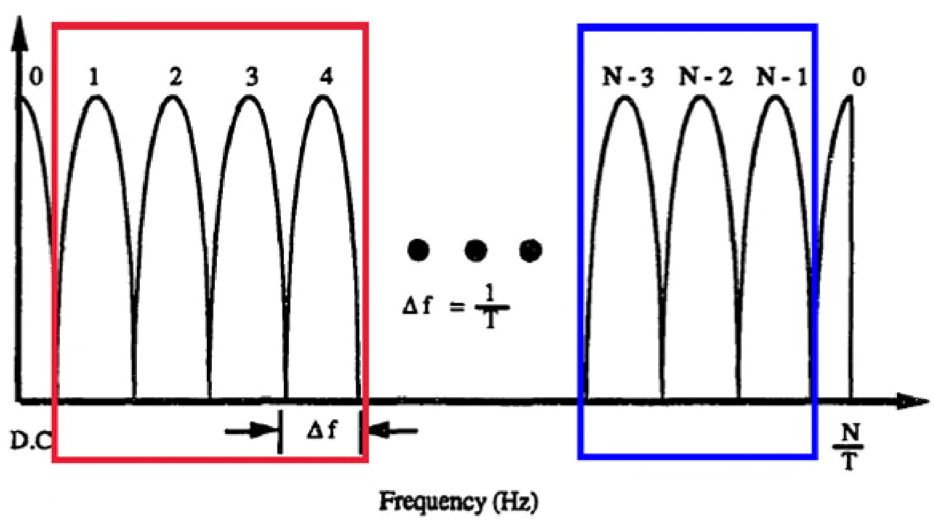


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5 (annotated).

371. As would have been appreciated by a person having ordinary skill in the art, there are many other first and second pluralities of carriers in the multicarrier symbols disclosed by

Chow. Specifically, any two or more carriers make up a first plurality of carriers, and any two or more carriers make up a second plurality of carriers. Although the carriers in the first plurality I identified above in Figure 2.5 are contiguous, there is no requirement for the carriers in the first plurality to be adjacent to each other, and the carriers in the second plurality need not be adjacent to each other, either. As shown in the annotated version of Figure 2.5 above, the subsets of two or more carriers can be disjoint so there is no overlap in the carriers of the first plurality and the carriers of the second plurality.

372. In addition, Figures 6.20 through 6.27 of Chow illustrate many first and second pluralities of carriers that are different from each other. In the annotated versions below, I have indicated locations for several possible first and second pluralities of carriers that are different from each other, where the different pluralities are indicated by different colors.

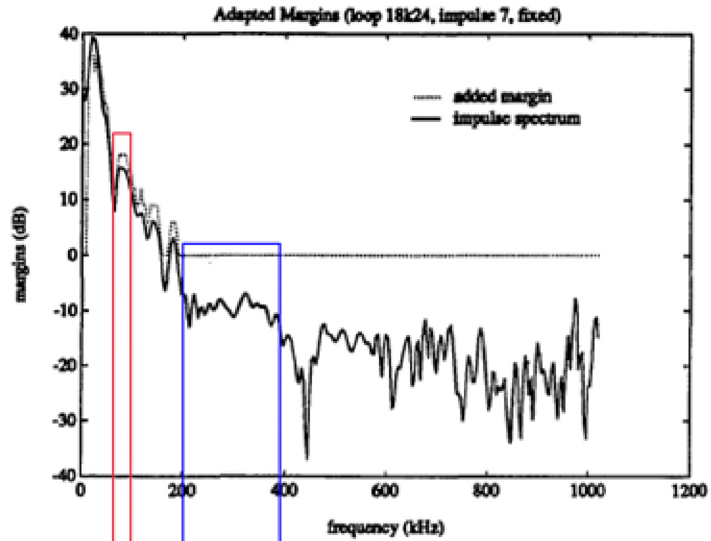


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

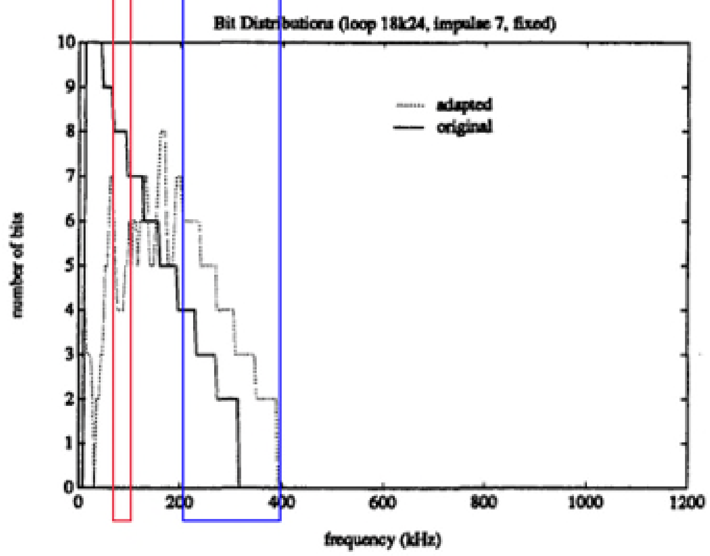


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Figs. 6.20 and 6.21 (annotated).

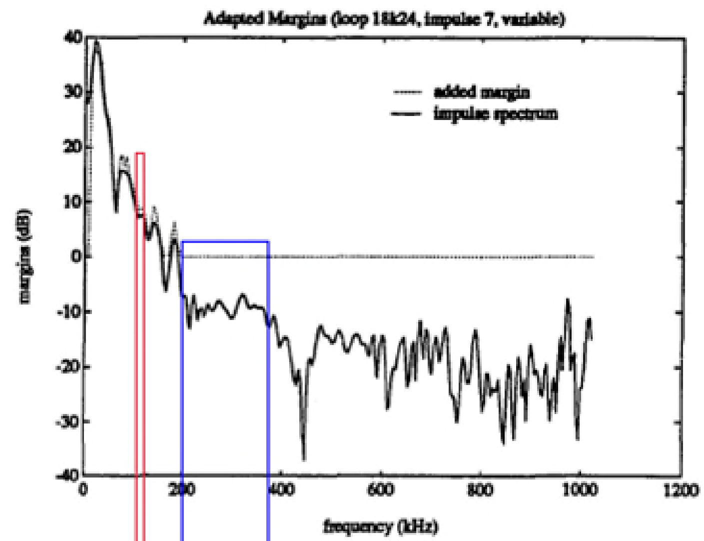


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

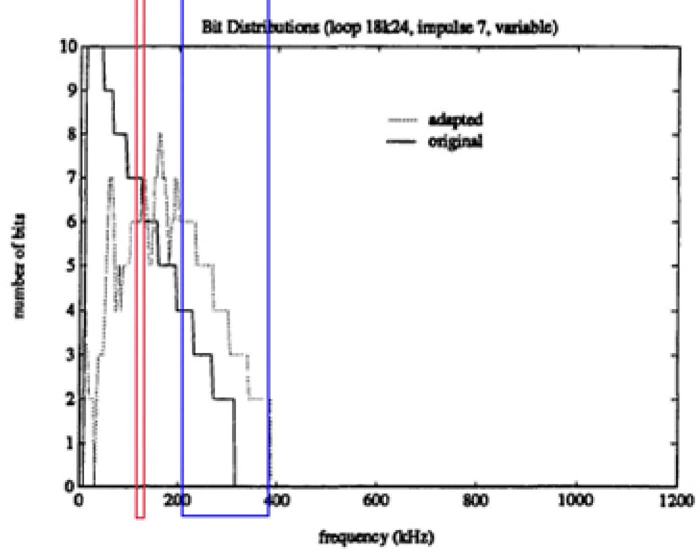


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Figs. 6.22 and 6.23 (annotated).

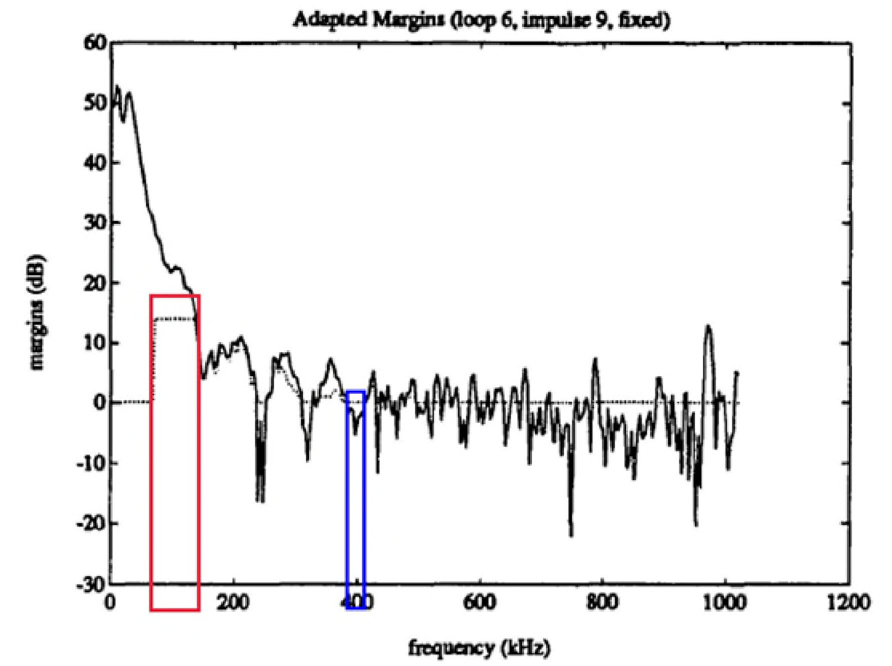


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24 (annotated).

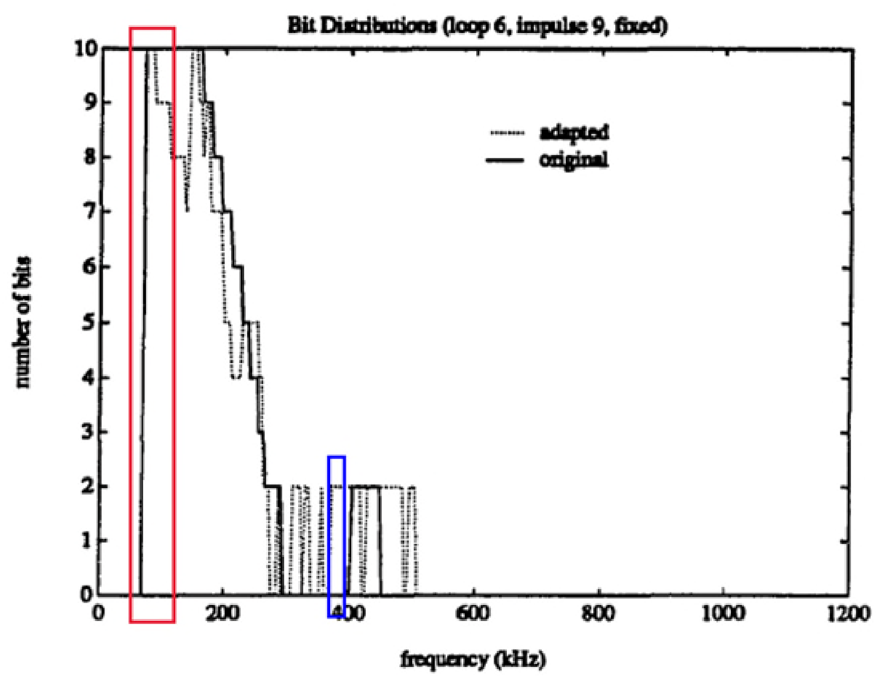


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25 (annotated).

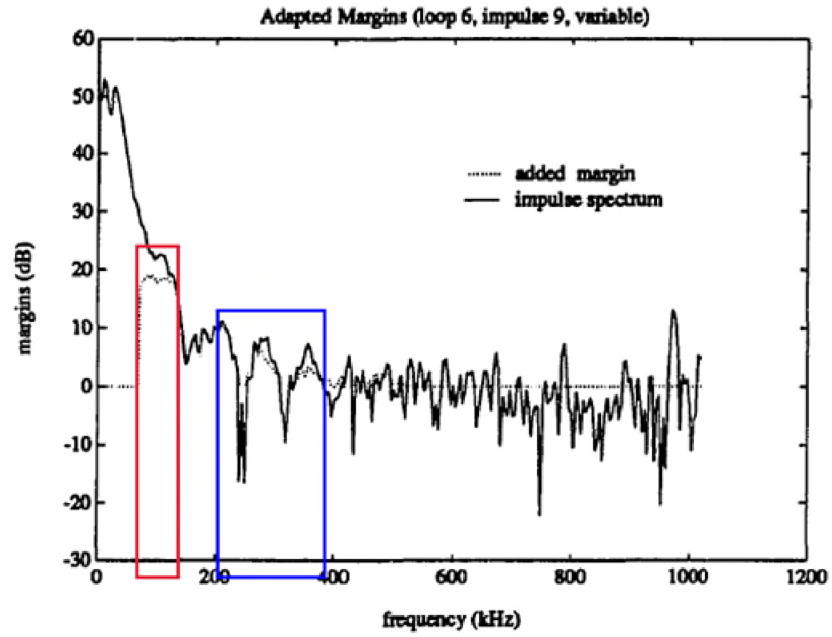


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26 (annotated).

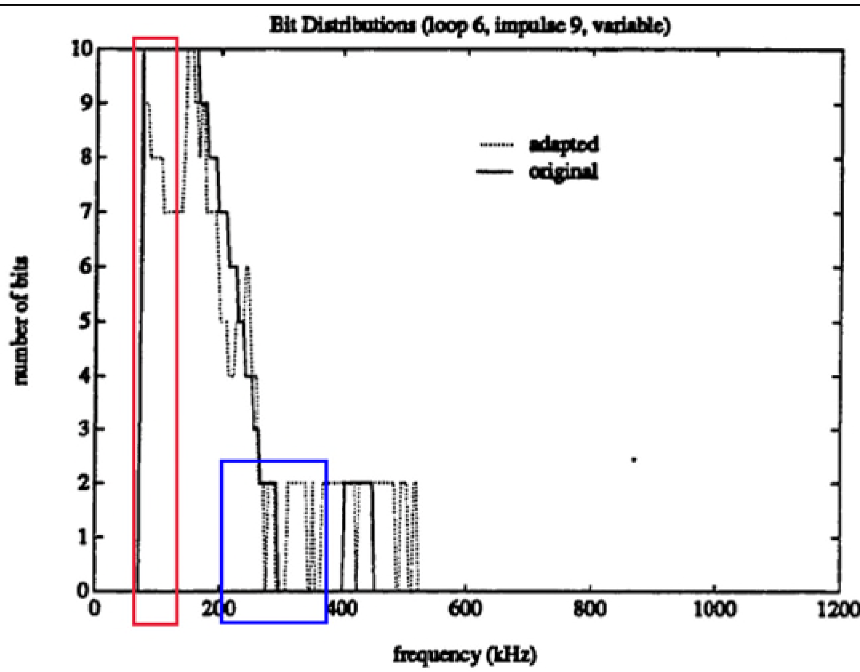


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27 (annotated).

373. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.e.

i. <u>Claim 10.f "wherein the first SNR margin is different than the second SNR margin,"</u>

374. Chow discloses and/or renders obvious claim 10.f "wherein the first SNR margin is different than the second SNR margin."

375. As shown in the annotated versions of Figures 6.20, 6.22, 6.24, and 6.26, copied below, Chow discloses that the first SNR margin (for the first plurality of carriers) is different from the second SNR margin (for the second plurality of carriers), because the added margin (the amount added to the "base" margin) is different for the two pluralities of carriers:

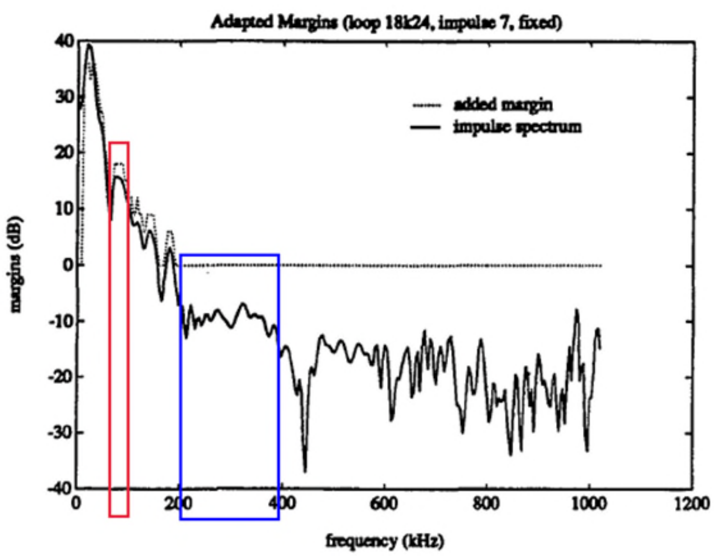


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20 (annotated).

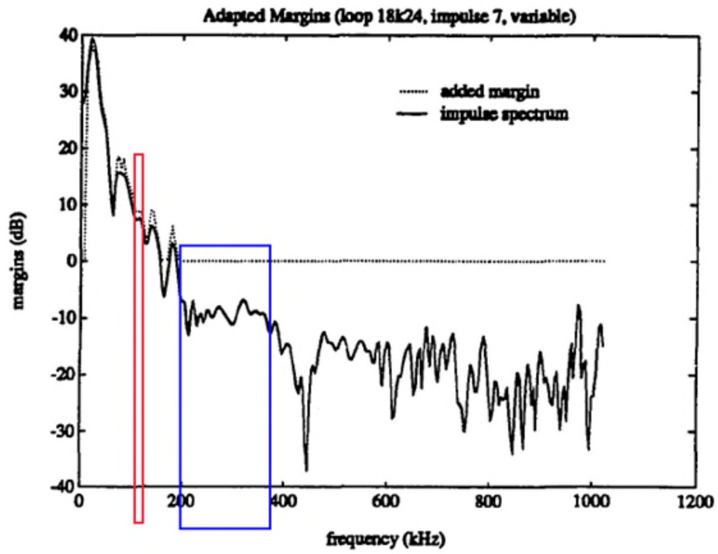


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22 (annotated).

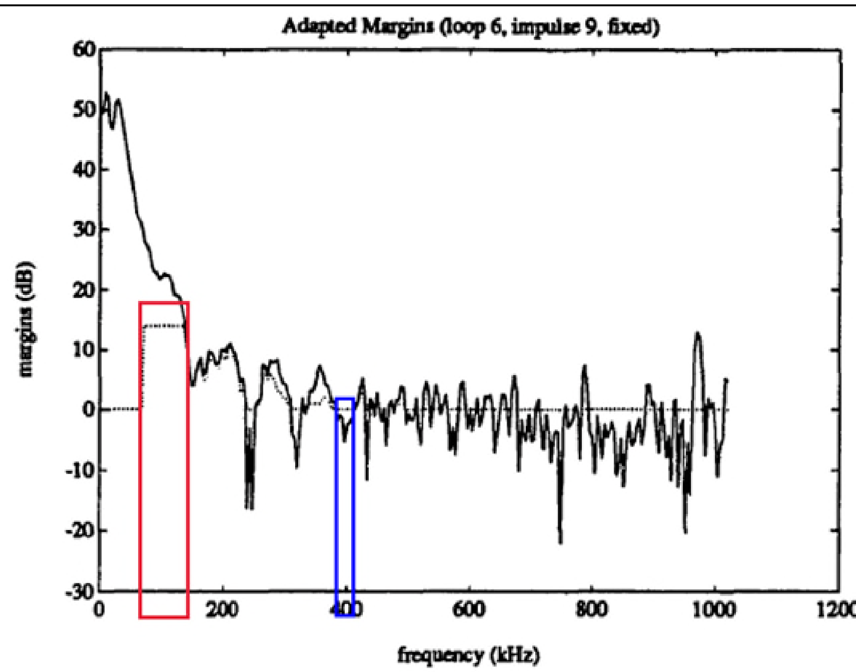


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24 (annotated).

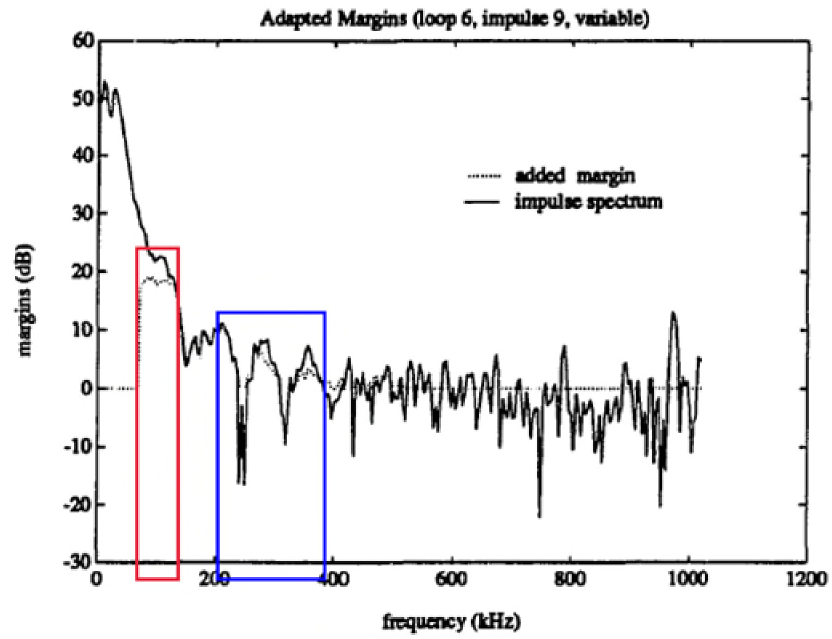


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26 (annotated).

376. "As is evident from the figure, this simple adaptation process will give additional margin to those tones most susceptible to the impulsive disturbance. . . . In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

377. Figure 6.22 indicates that updating the margins according to Equation (6.17) provides an improvement over adding fixed additional margin on each update. The resulting distribution of additional margin more closely follows the actual shape of the impulse spectrum than the margin distribution presented in Figure 6.20 for the case of constant updates. Furthermore, by comparing Figures 6.21 and 6.23, we find that the resulting bit distributions are indeed different for the two techniques. Figures 6.20 and 6.22 illustrate that the margin update

process successfully increases the amount of error protection on those tones most susceptible to a particular impulse noise." *Id.*

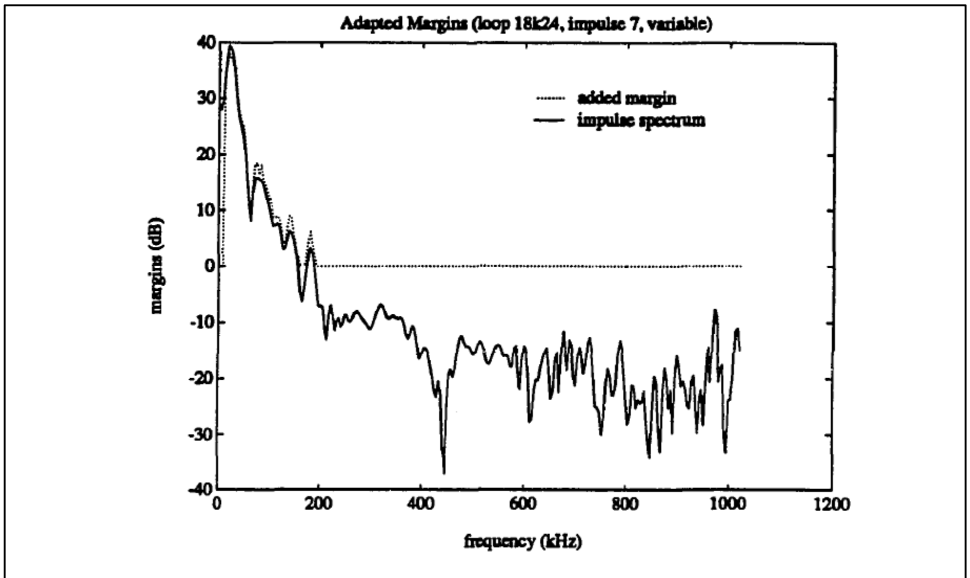


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

378. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

> Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones.

Id. at 158-60.

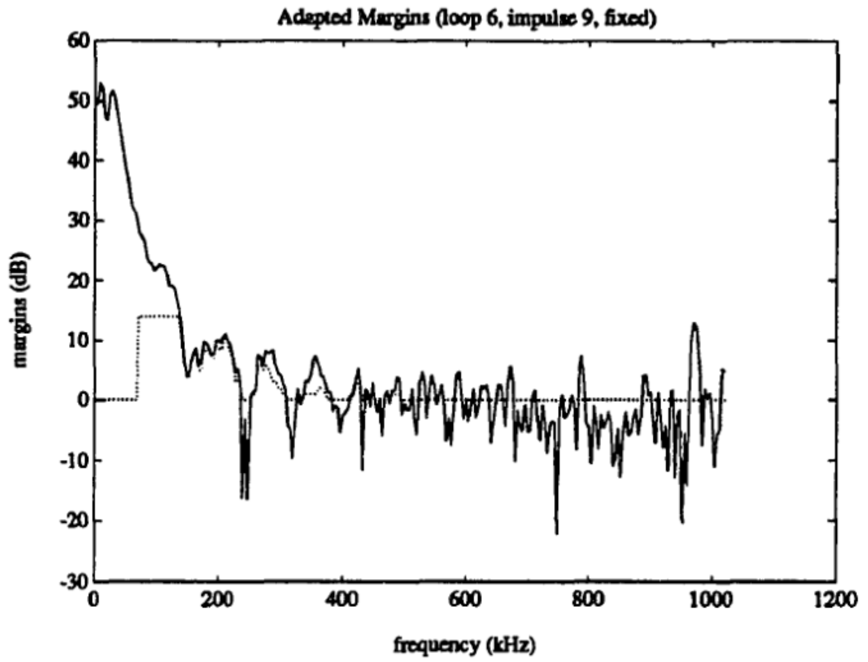


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

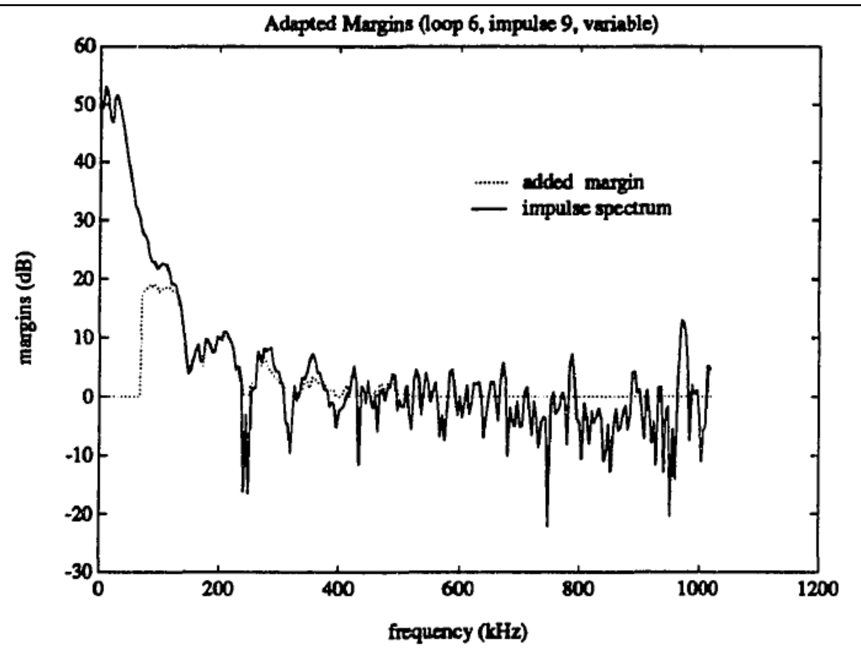


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26.

379. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.f.

j. <u>Claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."</u>

380. Chow discloses claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

381. As would have been understood by a person having ordinary skill in the art as of the priority date, for a given error probability, a higher SNR margin provides more robust reception than a lower SNR margin. Accordingly, by disclosing that, with an error probability of 10^{-7} (Chow, 86), a higher margin is used on one plurality of subchannels and a lower margin is used on a different plurality of subchannels, Chow discloses claim 10.g.

382. As shown in the annotated versions of Figures 6.20, 6.22, 6.24, and 6.26, copied below, Chow discloses that the first SNR margin (the amount of added margin used for the first plurality of carriers), indicated by the red boxes, is higher than the second SNR margin (the amount of added margin for the second plurality of carriers), indicated by the blue boxes.

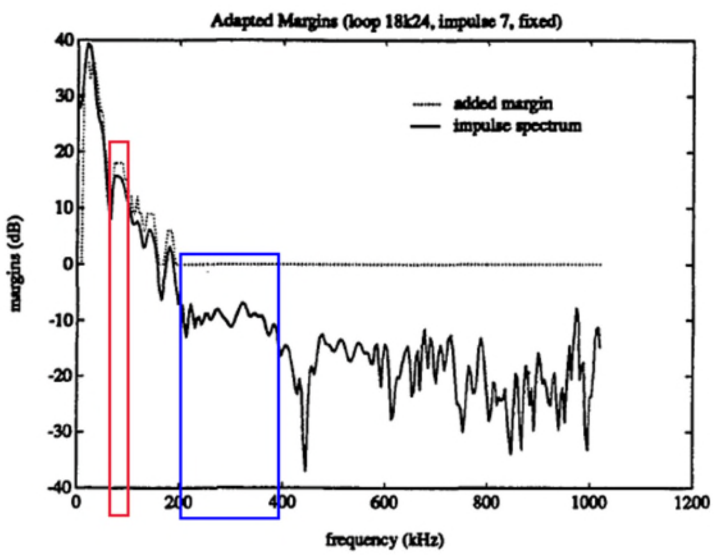


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20 (annotated).

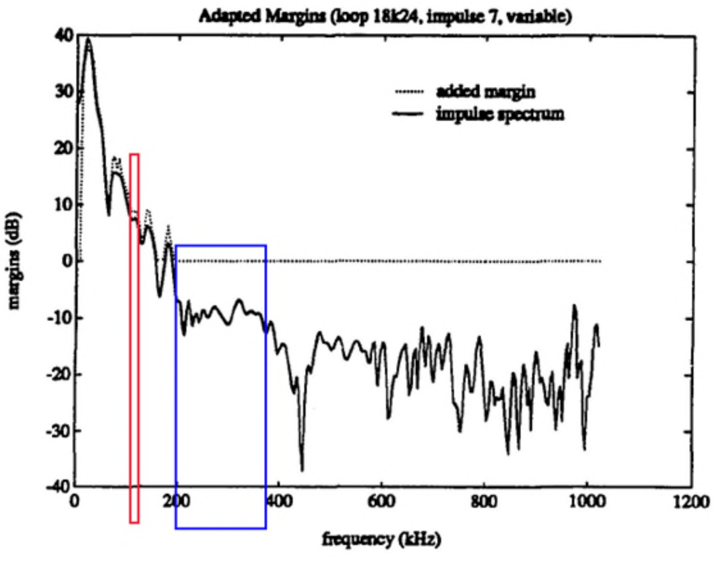


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22 (annotated).

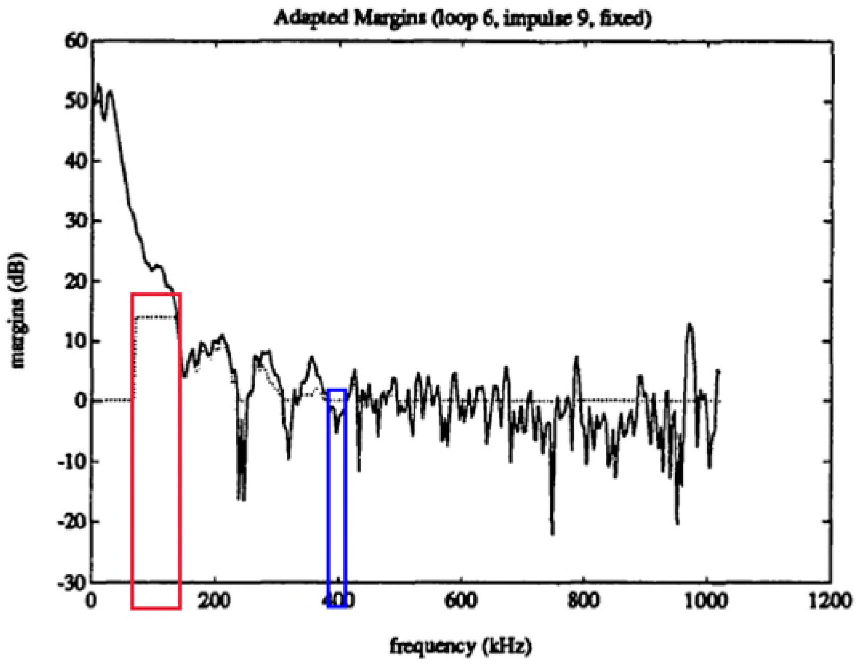


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24 (annotated).

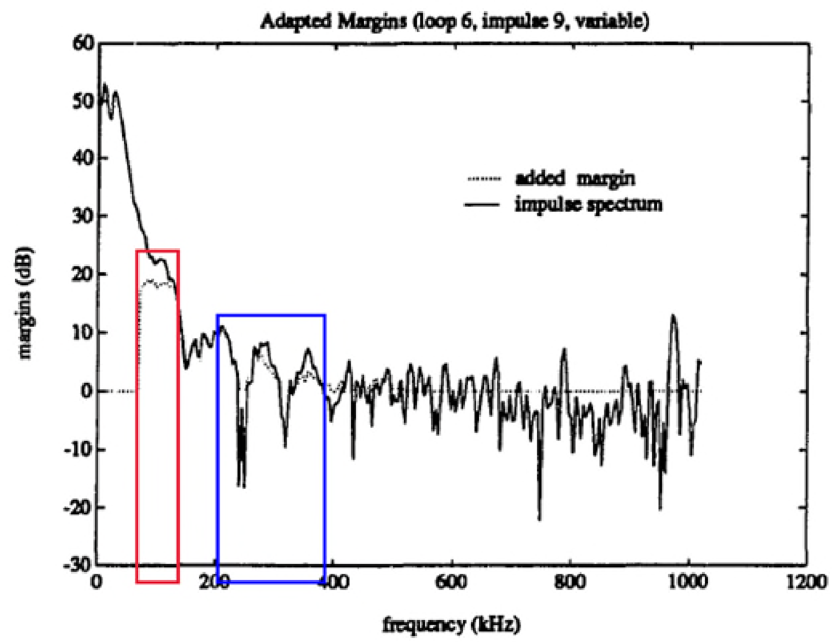


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26 (annotated).

383. Thus, the first SNR margin provides more robust reception than the second SNR margin, and Chow discloses claim 10.g.

384. "To aid the analysis of performance for both the DMT and the MMSE-DFE, we make use of a convenient single-parameter characterization of the system, known as the "SNR gap", $\Gamma(\Pr(E), C, \gamma$margin) [10], which is a function of the chosen coding scheme C, with a total effective coding gain of γeff(C) the target bit error rate (BER) $Pr(E)$, and the desired system performance (or noise) margin γmargin." *Id.* at 13. In clarifying this, Chow states "System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement." *Id.* at 13 n.1.

385. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will

be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

386. "As is evident from the figure, this simple adaptation process will give additional margin to those tones most susceptible to the impulsive disturbance. . . . In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers. *Id.* at 155.

387. Figure 6.22 indicates that updating the margins according to Equation (6.17) provides an improvement over adding fixed additional margin on each update. The resulting distribution of additional margin more closely follows the actual shape of the impulse spectrum than the margin distribution presented in Figure 6.20 for the case of constant updates. Furthermore, by comparing Figures 6.21 and 6.23, we find that the resulting bit distributions are indeed different for the two techniques. Figures 6.20 and 6.22 illustrate that the margin update process successfully increases the amount of error protection on those tones most susceptible to a particular impulse noise. However, as margin is reallocated, the performance of the other carriers will necessarily degrade." *Id.*

388. Thus, it is my opinion that Chow discloses and/or renders obvious claim 10.g.

389. Consequently, it is my opinion that claim 10 is anticipated by Chow and/or rendered obvious to a person having ordinary skill in the art in view of Chow.

5. U.S. Patent No. 6,516,027 to Kapoor et al. ("Kapoor") in View of Chow

390. Kapoor in view of Chow renders obvious each element of claim 10 of the '354 Patent.

a. Brief Description of Kapoor

391. U.S. Patent No. 6,516,027 to Kapoor et al. ("Kapoor") is titled "A Method and Apparatus for Discrete Multitone Communication Bit Allocation," and claims a priority date of February 18, 1999. Kapoor issued on February 4, 2004 from a patent application that was filed on February 18, 1999, and therefore constitutes prior art to the '354 Patent.

392. Kapoor discloses "[a] method and apparatus for allocating bits to subchannels in a discrete multitone environment." Kapoor at Abstract. In particular, the method disclosed in the patent "employs the use of precalculated and prestored look-up tables which take into account a desired bit error rate, signal to noise ratio gap for particular coding scheme, and gain scaling factor." *Id.* Kapoor describes techniques to determine "bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains." *Id.* at 8:39-42.

393. As noted above in §IX.A.1 Kapoor was considered by the examiner during the prosecution history. The examiner, however, failed to consider Kapoor in view of Chow. As discussed below, claim 10 of the '354 Patent is rendered obvious by Kapoor in view of Chow.

b. Brief Description of Chow

394. I provided a brief description of Chow above. *See supra* §XII.A.4.a, which I incorporate by reference here.

c. Motivation to Combine Teachings of Kapoor With Teachings of Chow

395. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Kapoor discloses Claim 10.pre "A multicarrier communications transceiver operable to."

396. In my opinion, as explained further below, a person having ordinary skill in the art would have been motivated to combine the teachings of Kapoor with the teachings of Chow as recited in claim 10 of the '354 Patent and would have had a reasonable expectation of success in making the combination.

397. Kapoor's objective is to provide bit loading (*i.e.*, the allocation of bits to subcarriers) techniques that improve on prior art algorithms. *See, e.g.*, Kapoor at Abstract, 3:7-4:21. In its background section, Kapoor teaches that "[t]he margin is the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap," where "[t]he SNR gap is measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel." *Id.* at 2:24-33. Kapoor also states that "[t]he need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments." *Id.* at 7:47-48.

398. A person having ordinary skill in the art would have understood the unforeseen additive noise impairments referred to by Kapoor to include, among other things, impulse noise because it was known as of the priority date that DSL channels suffer from impulse noise. For example, T1.413 Issue 1 defines tests for ADSL transceivers that include AWGN, crosstalk, and impulse noise. *See, e.g.,* T1.413 Issue 1, § 15.2.2 ("There are two impulse waveforms defined for testing. These are reconstructions of actual recorded impulses observed in field tests, and

represent the single most likely waveforms at specific sites."); *id.* at § 15.3.2 (defined test conditions include AWGN, crosstalk, and impulse noise, among others); *id.* at § 15.3.2.2 ("Impulse test" includes crosstalk interference set forth in tables in § 15.3.2.1, which tables say that "[t]he indicated interferers for each test are summed together with AWGN with PSD of -140 dBm/Hz to form a composite power spectral density."). *See also, e.g.*, COMMSCOPE072109 at COMMSCOPE072110 (D.647 (June 21-July 2, 1999)), § 6.2.2.1 ("The VDSL system is required to meet its reach and quality of service requirements with adequate margin (6 dB at 1e-7), considering crosstalk (*see* Section 6.2.1), impulse noise (*see* Section 6.2.3), system noise and broadband environmental noise (*see* Section 6.2.4) contributions, while at the same time the loop is subject to simultaneous RFI from multiple AM broadcast stations, and an adjacent amateur radio station."); COMMSCOPE072133 (D.748 (April 3-14, 2000)) at COMMSCOPE072136, COMMSCOPE072140-41 (distinguishing between performance with AWGN only and AWGN plus impulse noise). Accordingly, a person having ordinary skill in the art considering the communication systems of Kapoor would have known that impulse noise is a problem for DSL systems and would have been motivated to improve the robustness of Kapoor's communication systems in the presence of impulse noise.

399. Among other things, Chow's 187-page Ph.D. dissertation investigates techniques for improving the performance of DMT systems in the presence of impulse noise. Chow at 114-15. Chow notes that most practical communication systems are designed "with a built-in performance margin to take the detrimental effects of impulse noise into account." *Id.* at 114. Along similar lines, Kapoor states that prior art bit loading algorithms "do not support a bit allocation method which allows different subchannels to operate at different bit error rates or margins," but that it would be "desirable to have a method which can allocate bits to subchannels

based on a desired bit error rate, and further to be able to allow subchannels to operate at different bit error rates." Kapoor at 4:8-10, 17-21.

400. Kapoor teaches that its techniques allow different subchannels to "have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains. . . ." *Id.* at 8:39-42. Kapoor thus discloses that different margins can be used on different subchannels. But Kapoor does not describe in detail how to determine what the different margins on the different subchannels should be, or under what conditions the use of different margins on different subchannels might be advantageous. Accordingly, a person having ordinary skill in the art would have sought references addressing these shortcomings of Kapoor.

401. Chow teaches that the use of different margins on different subchannels can improve robustness in the presence of impulse noise. Specifically, Chow discloses that "[i]f the DMT transceiver can adaptively learn the spectral shape of the impulse noise and there is sufficient extra margin available, then the extra margin can be placed intelligently on those tones most susceptible to errors due to impulse noise." Chow at 114, 151. Thus, Chow teaches that the performance of a DMT system can be improved by detecting whether a subchannel is suffering from impulse noise and, if it is, allocating excess margin to that subchannel.

402. Chow teaches monitoring "the occurrence of a large number of unusually high error signals over the carriers in a DMT symbol" and using a threshold to decide whether "the error signal on a particular subchannel is 'unusually high.'" *Id.* at 151. When more than a threshold number of subchannels have been found to have unusually high error signals, Chow teaches that an impulse is likely to be present. *Id.* In response, "the estimate of the impulse spectrum is updated, using the mean squared error signals on all of the subchannels." *Id.* at 151-52. Chow defines a running sum, α_{ij}, which is the impulse spectral estimate on subchannel *i* at

time *j*. *Id.* at 152. Chow also defines another threshold, *impthresh*, and teaches that after some number of suspected impulse occurrences, "additional margin will be given to those subchannels with mean squared error estimates, α_{ij}," that exceed *impthresh*. *Id.* Chow explains in detail how to determine how much additional margin to allocate to each subchannel whose mean squared error estimate, α_{ij}, exceeds *impthresh*, and Chow presents the results of multiple simulations illustrating the effect of the disclosed techniques. *See id.* at 152-61.

403. A person having ordinary skill in the art would have been motivated to improve the communication systems of Kapoor to improve robustness to impulse noise. In view of Kapoor's teaching that prior-art bit allocation techniques were suboptimal because they did not allow different subchannels to operate at different margins, a person having ordinary skill in the art would have been motivated to incorporate Chow's impulse-noise-detection and excess-margin-allocation techniques to the bit loading algorithms of Kapoor in order to improve system performance and overcome a drawback of the prior art specifically noted by Kapoor. As would have been appreciated by those having ordinary skill in the art as of the priority date, the result of applying Chow's teachings to the communication systems of Kapoor would be that different subchannels would have different margins, as Kapoor discloses would be desirable.

404. A person having ordinary skill in the art would thus have been motivated to add the impulse-noise-detection and excess-margin-allocation techniques of Chow to the communication devices of Kapoor, and would have found it trivial to do so. The disclosures of Chow are complementary to those of Kapoor, and it would have been obvious to a person having ordinary skill in the art to incorporate the teachings of Chow on how to allocate additional margin to subchannels suffering from impulse noise into the communication systems of Kapoor. Specifically, a skilled artisan would have used Chow's impulse-noise-detection and excess-

margin-allocation techniques to adjust the measured SNRs before running the bit loading algorithm, as taught by Kapoor. *See, e.g.*, Kapoor at 8:29-32. More specifically, Kapoor describes reducing the measured SNR of each subchannel by the difference between the margin and the coding gain (*i.e.*, by the quantity $\gamma_{margin} - \gamma_{coding}$), and then determining the bit allocation and gain scaling values using the resulting reduced measured SNR values. *See, e.g.*, *id.* at 7:43-10:46. Based on the teachings of Chow, a person having ordinary skill in the art would have been motivated to use impulse-noise-detection and excess-margin-allocation techniques to determine the additional margin for each subchannel, and then, as taught by Kapoor, to reduce each subchannel's measured SNR value by the value determined by Chow's techniques, because doing so would improve performance by providing more protection to subchannels known to be affected by impulse noise. In other words, a person having ordinary skill would have used, for a particular subchannel, the sum of the common (base) margin (e.g., 6 dB) and the additional margin determined using Chow's impulse-noise-detection and excess-margin-allocation techniques as the γ_{margin} value to adjust the measured SNR of that subchannel in Kapoor's system before performing the bit allocation techniques of Kapoor. A skilled artisan would have found this modification trivial, particularly because Kapoor discloses that different margins can be used for different subchannels, and Chow teaches the use of higher margins on subchannels that are affected by impulse noise, and it also teaches how to find such subchannels and how to determine how much additional margin to add to them. Chow also teaches that the disclosed techniques are more attractive than alternatives because they "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible," which "is more desirable than merely increasing the transmit power applied to susceptible subchannels and decreasing the transmit power on other subchannels," which would "lead to a

wide variation in the level of transmit power across the transmission band." Chow at 153. Thus, a person having ordinary skill in the art would have recognized that adding the specific techniques of Chow to the communication systems of Kapoor would offer additional power advantages.

405. A person having ordinary skill in the art would have had a strong expectation of success in combining Chow's teachings (*e.g.*, detecting subchannels affected by impulse noise and adding extra margin to each such subchannel prior to bit loading) with Kapoor's bit allocation procedures that allow the noise margin, error probability, and coding gain to vary from subchannel to subchannel. The addition of Chow's impulse-noise-detection and excess-margin-allocation techniques to the systems of Kapoor would have been trivial because Chow's impulse-noise-detection and excess-margin-allocation techniques and Kapoor's bit allocation techniques are complementary and fit together like pieces of a simple puzzle.

406. It is clear from the figures of Chow (*see, e.g.*, Chow at Figures 6.20, 6.22 6.24, 6.26) that the result of combining the teachings of Chow with those of Kapoor as described herein would result in Kapoor's communication system including a multicarrier communications transceiver operable to receive a multicarrier symbol comprising a first plurality of carriers and a second plurality of carriers (wherein the first plurality of carriers is different than the second plurality of carriers); receive a first plurality of bits on the first plurality of carriers using a first SNR margin; receive a second plurality of bits on the second plurality of carriers using a second SNR margin (wherein the first SNR margin is different than the second SNR margin, and the first SNR margin provides more robust reception than the second SNR margin). Taking Figure 6.20 as just one example, an annotated version of which is shown below, it is clear that adding Chow's impulse-noise-detection and excess-margin-allocation techniques to the communications systems of Kapoor would result in there being multiple pluralities of subchannels that have the same added

margin, whatever it might be (each red oval), and multiple pluralities of subchannels that have no added margin (blue oval). Thus, for example, if the base margin is 6 dB, as is customary in DSL, there are multiple pluralities of subchannels that have the same greater-than-6 dB margin (e.g., two or more subchannels within any one of the red ovals), and there are multiple pluralities of subchannels that have 6 dB margin (e.g., any two or more subchannels above 200 kHz).

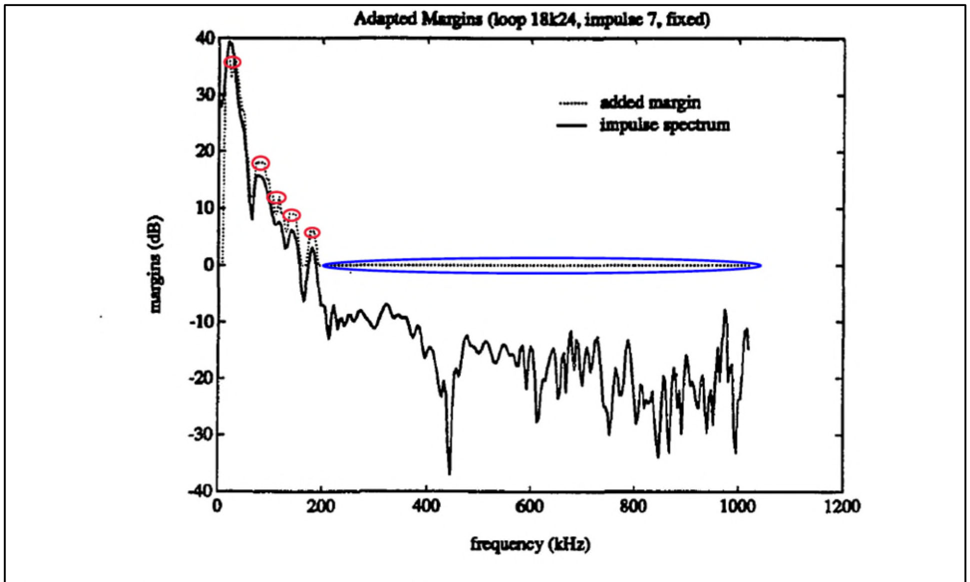


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20 (annotated).

407. As would have been understood by a person having ordinary skill in the art, adjusting Kapoor's measured SNRs by the base SNR and the added margins described in Chow and then executing Kapoor's bit loading algorithm would result in more robust reception on those subchannels with Chow's added margin, as recited in claim 10.

d. <u>Claim 10.pre "A multicarrier communications transceiver operable to:"</u>

408. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Kapoor discloses Claim 10.pre "A multicarrier communications transceiver operable to."

409. Kapoor discloses a multicarrier communications transceiver that is used in a DMT communication system. For example, Kapoor details a method and apparatus for discrete multitone communication bit allocation. Kapoor at Title. Kapoor relates to a discrete multitone modulation ("DMT") communication system. "The present invention relates to data communications, specifically to an apparatus and method for allocating bits among carrier tone subchannels (bins) in a discrete multitone modulation (DMT) communication system." *Id.* at 1:7-11.

410. Kapoor also discusses SNR gaps that depend on the modulation and coding used in a transmitter. "The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure that the received SNR in the i subchannel corresponds to bi bits in that Subchannel." *Id.* at 3:58-67.

411. Moreover, the method and apparatus operates over a computer, that connects with a DSL network interface and a DTE interface. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16; *Id.* at Figure 2.

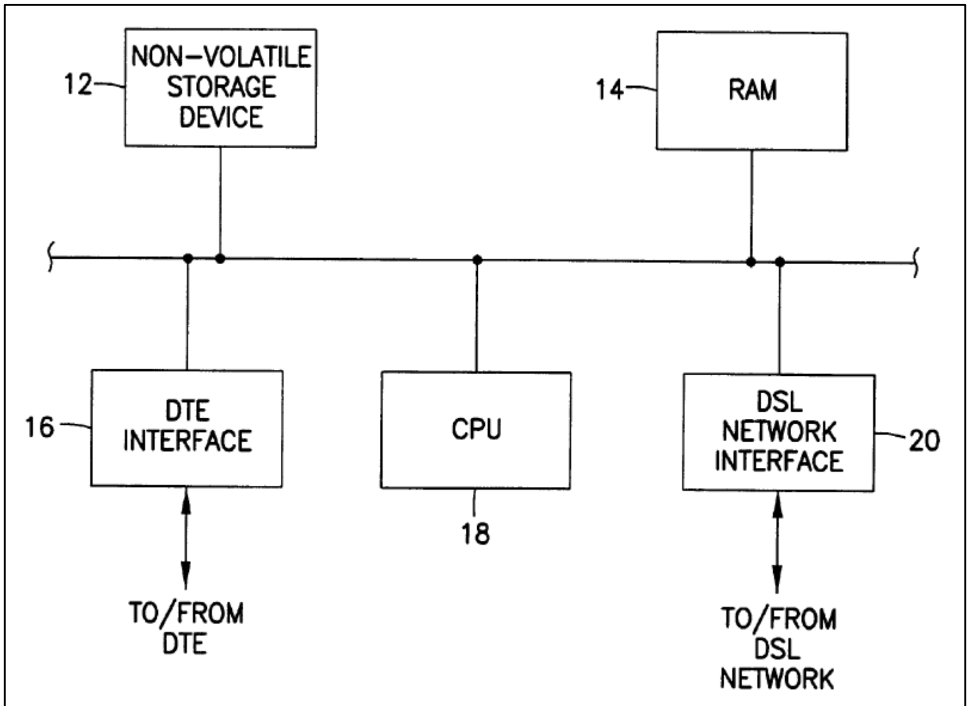


Fig. 2

Kapoor at Fig. 2.

412. Thus, it is my opinion that Kapoor discloses the preamble of claim 10, to the extent it is limiting.

e. Claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers"

413. Kapoor discloses claim 10.a "receive a multicarrier symbol comprising a first plurality of carriers."

414. Kapoor discloses that the multicarrier communications transceiver is operable to receive a multicarrier symbol. "Subsequent DMT multicarrier modulation equipment made use of digital signal processing techniques including Fast Fourier Transforms and Inverse Fast Fourier Transforms. Digital signal processing allowed a single DMT communication device to be used to modulate all subchannels, thereby improving reliability and lowering the cost of communications." *Id.* at 2:7-13.

415. Kapoor discloses that each multicarrier symbol comprises a plurality of carriers. "A preferred approach is to load each subchannel based on the individual transmission characteristics of that subchannel. Better subchannels, should carry more information than poorer quality subchannels. This allows an efficient use of the communication channel resources." *Id.* at 2:16-20. The indication of multiple subchannels means there are a plurality of carriers. The underlying invention in Kapoor allows for SNR ratios are measured for each plurality of subchannels in a communication system, which is consistent with having a plurality of channels with different SNR ratios as disclosed in the '354 Patent.

416. In addition, Kapoor discloses that "the number of subchannels can be quite large (over 100 in many cases)." *Id.* at 3:37-39. Any two or more of these over 100 subchannels are a first plurality of carriers.

417. In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a corresponding plurality of respective bit values, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to noise ratio values also correspond to the plurality of respective bit values. It is another object of the present invention to provide a method of allocating bits to a plurality of transmission subchannels in a communication system, in which a measuring step measures a signal-to-noise ratio for each of the plurality of transmission subchannels. An adjusting step adjusts the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain. *Id.* at 4:32-46.

418. Moreover, different pluralities of carriers are accomplished in Kapoor via the different subchannels which each have bit allocation values. "Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error

rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:39-42.

419. Kapoor discloses receiving a multicarrier symbol. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16.

420. Moreover, different pluralities of carriers are grouped in Kapoor via the different subchannels which each group having different bit allocation values. "Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:36-42.

421. Kapoor discloses at least two pluralities of carriers in Fig. 5 shown below and its associated text. Specifically, Fig. 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

422. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated)

423. Kapoor discloses receiving a multicarrier symbol. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16.

424. Thus, Kapoor discloses claim 10.a.

f. **<u>Claim 10.b "and a second plurality of carriers"</u>**

425. Kapoor in view of Chow discloses claim 10.b "and a second plurality of carriers."

426. Kapoor discloses different subchannels, thus indicating that there is a second plurality of carriers. "Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:39-42.

427. Different pluralities of carriers are grouped in Kapoor via the different subchannels which each group having different bit allocation values. "Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:36-42.

428. Kapoor discloses at least two pluralities of carriers in Fig. 5 shown below and its associated text. Specifically, Fig. 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

429. Moreover, Kapoor expressly discloses a "plurality of transmission subchannels." "A processing unit determines a bit allocation value and again scaling factor for each of the plurality of transmission subchannels in accordance with the at least one stored bits to signal-to-noise ratio table." *Id.* at 4:59-62.

430. In addition, Kapoor discloses that "the number of subchannels can be quite large (over 100 in many cases)." *Id.* at 3:37-39. Any two or more of these over 100 subchannels that are not included in the first plurality of carriers are a second plurality of carriers.

431. Thus, it is my opinion that Kapoor discloses claim 10.b.

432. I explained above (*see supra*, § XII. A.4.e) that Chow also discloses this element. I incorporate that explanation by reference here.

433. As I explained above (*see supra*, § XII.A.5.c, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

434. Thus, it is my opinion that Kapoor in view of Chow discloses claim 10.b.

g. <u>Claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin;"</u>

435. Kapoor in view of Chow discloses claim 10.c "receive a first plurality of bits on the first plurality of carriers using a first SNR margin."

436. The Court has construed "SNR margin" as "a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

437. Kapoor discloses using a margin that meets the Court's definition for SNR Margin. Kapoor describes the "SNR gap" or "margin" as "the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap." Kapoor at 2:21-27.

438. Further, the "SNR gap is a function of a chosen probability of transmission error and the modulation and coding techniques. The SNR gap measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel. The SNR gap is often constant over a wide range of transmission rates which may be transmitted by the particular modulation coding technique. The channel capacity refers to the maximum data rate capable of being transmitted on a particular channel. The optimum line coding technique has a SNR gap of zero dB. Although such an optimum line code requires infinite decoding/encoding delay and is infinitely complex, it has become practical at typical Digital Subscriber Line (DSL) speeds to implement modulation methods to achieve SNR gaps as low as 1-2 dB. Therefore, one factor to be considered during the bit allocation process is the transmission quality of each subchannel, in order to maximize the bit allocation for each subchannel." *Id.* at 2:21-45.

439. For the SNR required to maintain a specified BER, Kapoor discloses: "the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit

error rate (BER)." *Id.* at 3:59-61. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

440. Kapoor further describes how the SNR margin is used in connection with bit allocation:

> The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory.

Id. at 5:1-12.

441. Transmission channels are typically characterized by the channels margin, signal to- noise ratio gap (hereinafter SNR gap), and capacity. All are related concepts. The margin is the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap. The SNR gap is a function of a chosen probability of transmission error and the modulation and coding techniques. The SNR gap measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel. The SNR gap is often constant over a wide range of transmission rates which may be transmitted by the particular modulation coding technique. The channel capacity refers to the maximum data rate capable of being transmitted on a particular channel. The optimum line coding technique has a SNR gap of zero dB. Although such an optimum line code requires infinite decoding/encoding delay and is infinitely complex, it has become practical at typical Digital Subscriber Line (DSL)

speeds to implement modulation methods to achieve SNR gaps as low as 1-2 dB. Therefore, one factor to be considered during the bit allocation process is the transmission quality of each subchannel, in order to maximize the bit allocation for each subchannel. *Id.* at 2:21-45.

442. In addition, Kapoor discloses SNR margins. "The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory." *Id.* at 5:1-12. These SNR margins are have a corresponding bit value as disclosed in Kapoor. "In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a corresponding plurality of respective bit values, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to-noise ratio values also correspond to the plurality of respective bit values." *Id.* at 4:32-39. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

443. Thus, it is my opinion that Kapoor discloses claim 10.c.

444. I explained above (*see supra*, § XII.A.4.f) that Chow also discloses this element. I incorporate that explanation by reference here.

445. As I explained above (*see supra*, § XII.A.5.c, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor, 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

446. Accordingly, Kapoor in view of Chow discloses claim 10.c.

h. Claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin;"

447. Kapoor in view of Chow discloses claim 10.d "receive a second plurality of bits on the second plurality of carriers using a second SNR margin."

448. I incorporate by reference my analysis for claim elements 10.pre, 10.a, 10.b, and 10.c.

449. The plurality of subchannels in Kapoor show that the reference discloses that each of the subchannels (carriers) has a separate SNR margin and that each subchannel has a different bit allocation value.

450. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

451. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated).

452. The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission

subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory. *Id.* at 5:1-12.

453. A plurality is construed as meaning more than one, thus, there is a second plurality of bits on a second plurality of carriers which uses a second SNR margin.

454. Thus, it is my opinion that Kapoor discloses claim 10.d.

455. I explained above (*see supra*, § XII.A.4.g) that Chow also discloses this element. I incorporate that explanation by reference here.

456. As I explained above (*see supra*, § XII.A.5.c, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

457. Accordingly, Kapoor in view of Chow discloses claim 10.d.

i. <u>Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers,"</u>

458. Kapoor in view of Chow discloses Claim 10.e "wherein the first plurality of carriers is different than the second plurality of carriers."

459. Kapoor discloses that a subset of channels differ from a different sunset of channels such that it constitutes that carriers are different. Although the above description is directed to a bit allocation process in which all subchannels are analyzed and bits allocated, an

alternative embodiment exists in which the bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. For example, when the communication device has completed its training sequence and is operating in 'showtime', line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels. "[T]he bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. . . . line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels." *Id.* at 11:35-42. Here, where the process is completed for a set of subchannels and not for the other set of subchannels, it then follows that there is a difference in the first plurality of carriers versus the second plurality of carriers.

460. Thus, it is my opinion that Kapoor discloses claim 10.e.

461. I explained above (*see supra*, § XIIA.4.h) that Chow also discloses this element. I incorporate that explanation by reference here.

462. As I explained above (*see supra*, § XII.A.5.c, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins

would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

463. Accordingly, Kapoor in view of Chow discloses claim 10.e.

j. <u>Claim 10.f "wherein the first SNR margin is different than the second SNR margin,"</u>

464. Kapoor in view of Chow discloses claim 10.f "wherein the first SNR margin is different than the second SNR margin." I incorporate by reference by analysis for claim element 10.d.

465. Kapoor discloses that "[w]ithin this inventive system and method, a framework is provided which also supports the use of different $P_e/2$ rates and SNR margins for different subchannels in a communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55. As stated in Kapoor, different SNR margins can be used for different subchannels.

466. Thus, it is my opinion that Kapoor discloses claim 10.f.

467. I explained above (*see supra*, § XII.A.4.i) that Chow also discloses this element. I incorporate that explanation by reference here.

468. As I explained above (*see supra*, § XII.A.5.c, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins

would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

469. Accordingly, Kapoor in view of Chow discloses claim 10.f.

k. Claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

470. Kapoor in view of Chow discloses claim 10.g "and wherein the first SNR margin provides more robust reception than the second SNR margin."

471. Kapoor discloses the contrast between SNR margins such that one can determine which is more robust. "Once an SNR_{vec} and SNR_{maxvec} table has been stored for a particular number of bits, the process can be repeated to create a table for a different BER (step 28). Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:34-42.

472. Moreover, Kapoor discloses that "because multiple tables corresponding to different $P_e/2$ values can be predetermined and stored, it is possible to allocate bits and establish gain scaling values for different subchannels using different P/2 values for those subchannels. For example, a $P_e/2$ value of 10^{-7} can be used to determine bit allocation and gain scaling for some subchannels, and a $P_e/2$ value of 10-8 can be used for the remaining subchannels. Of course, there is no limit to the number of different $P_e/2$ values which can be used, subject only the quantity of SNR tables stored in the communication device." *Id.* at 10:36-46.

473. Thus, it is my opinion that Kapoor discloses claim 10.g.

474. I explained above (*see supra*, § XII A.4.j) that Chow also discloses this element. I incorporate that explanation by reference here.

475. As I explained above (*see supra*, § XII.A.5.c, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

476. Consequently, it is my opinion that claim 10 would have been obvious to a person having ordinary skill in the art in view of Kapoor.

477. Thus, Claim 10 is rendered obvious by Kapoor in view of Chow.

B. <u>'988 Patent</u>

1. <u>European Patent Application No. 0,753,948 to Peeters ("Peeters")</u>

478. Peeters discloses each element of claim 16 of the '988 Patent.

a. <u>Brief Description of Peeters</u>

479. I provided a brief description of Peeters above. *See supra* §XII.A.1.a, which I incorporate by reference here.

b. <u>Claim 16</u>

480. Claim 16 of the '988 Patent is disclosed in view of Peeters.

c. Claim 16.pre "An apparatus comprising: a multicarrier communications transceiver"

481. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Peeters discloses claim 16.pre "An apparatus comprising: a multicarrier communications transceiver." Peeters is used in ADSL applications but can also be implemented in DMT systems. *Id.* at 7:54-57, 3:47-58, claim 11. Peeters describes a modem "which transmits and receives digital data on a set of carriers called an ensemble of carrier frequencies." *Id.* at 2:8-9. "The modem includes a system for variably allocating data elements or data, and power to the 10 carrier frequencies to be transmitted via a telephone line." *Id.* at 2:9-10.

482. Peeters discloses the preamble of claim 16, to the extent it is limiting.

d. Claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier"

483. Peeters discloses claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier."

484. Peeters discloses transmitting and receiving a multicarrier symbol that comprises a set of 256 (plurality) of carriers. Peeters specifically references "the draft ANSI standard on ADSL" that has requirements for transmitting and receiving a multicarrier symbol with a plurality of carriers with at least:

> According to the draft ANSI standard on ADSL, mentioned already in the introductory part, the Discrete Multi Tone modulator MOD modulates data elements applied to its first input Ml1 on a set of 256 carriers having equidistant frequencies, and further applies the modulated carriers **via its output MO to a twisted pair telephone line**, not shown in the figure.

Id. at 4:35-38.

> Due to the effective impulse response length of the transmission line however, intersymbol interference will occur. Such intersymbol interference can be compensated by an adaptive filter **at the receiver's side**. In known solutions and

> **also suggested in paragraph 6.10 of the above cited draft Standard**, such a digital filter technique at the **receiver's side** is combined with cyclic prefix extension at the **transmitter's side** to obtain sufficient intersymbol interference compensation.

Id. at 4:52-56.

485. Peeters describes a method wherein the data and power are allocated for each carrier frequency by "measuring for each carrier frequency the signal noise ratio (SNR)." *Id.* at 2:10-13. The "equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER) to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation." *Id.* at 2:13-16. "The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity." *Id.* at 2:19-21. All data elements are treated in an identical way, however, several types of data, each of which characterized by its own requirement sand specifications, can be distinguished. *Id.* at 2:21-25.

486. Peeters further discloses that each "group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors . . . . Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data." *Id.* at 2:33-38.

487. Peeters further discloses that subsets of carrier groups can be grouped together and assigned certain data:

> To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier

> criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. **4 carriers is then associated with a first group of data elements**, a second subset of e.g. 7 carriers is associated with a second group of data elements having e.g. lower noise 20 compensation requirements than the first group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and there-fore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed

Id. at 3:16-24.

488. Peeters therefore discloses a multicarrier transceiver operable to demodulate for reception a first plurality of bits wherein this subset of carriers *e.g.,* 4 carriers, is associated with a first group of data elements. *See id.*

489. Thus, Peeters discloses claim 16.a.

e. Claim 16.b "using a first Signal to Noise Ratio (SNR) margin"

490. Peeters discloses claim 16.b. "using a first Signal to Noise Ratio (SNR) margin."

491. The Court has construed "SNR margin" as "a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

492. Peeters meets the Court's definition for SNR margin. For the SNR required to maintain a specified BER, Peeters discloses:

> Obviously, this is equal to measuring for each carrier frequency **the signal noise ratio (SNR) provided** that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, **the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER)** to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation.

> As stated on lines 26-27 of column 11 of US Patent 4,679,227, **these signal noise ratios** necessary for transmission of the data elements **are well known in the art**, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. **In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate**. The known method and modem however treat all data elements in an identical way.

Peeters at 2:11-22

493. For the SNR margin, Peeters discloses an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link. This extra SNR requirement is based on e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, … with at least:

> In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished.
>
> An object of the present invention is to provide a method and equipment of the above known type but **which take into account data depending requirements for noise compensation, transmission rate and so on**, and **wherein data element allocation and transmission for each type of data are thus tuned to its own specifications.**
>
> According to the invention, this object is achieved in the method, mapping unit and modulator described in claims so 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N groups of data elements. Each group of data elements becomes modulated on a subset of carriers, **these carriers being selected out of the full available set of carriers in accordance with another specific criterion**, called a **predetermined carrier criterion**, e.g. **the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ...** Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data.

> In addition, **by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table**, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, **noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table** which renders the allocation method more accurate.
>
> A further feature of the present data allocation method is that in a particular first implementation thereof, **the predetermined data criterion is equal to service dependent required compensation for occasional noise increase**. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The **predetermined carrier criterion** in this first implementation **is defined as the sensitivity of a carrier for such occasional noise increase.**

Id. at 2:26-47.

494. Peeters describes performing the calculations for each carrier using the measured SNR and the SNR margin with:

> These SNR margins are first calculated for each carrier in subset 1 **by subtracting the requested SNR from the SNR value measured on each of these carriers.** Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively. Since 5 the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5.

Id. at 6:59-7:10.

495. As discussed above, the transmitter's input data elements are classified into two groups based on the requirements with respect to interleaving and fast data. *Id.* at 6:23-24. "Once classified, each data element can be considered to carry a label defining whether it forms part of the group of interleaved data or of the group of fast data." *Id.* at 6:25-26. **The carriers are then**

divided into two subsets. *Id.* at 6:30. Next, the method considers "the carriers f1 ... f 11 being arranged in decreasing order of noise sensitivity," and "**the third step is executed by defining the last carrier in the sequence which belongs to subset 1**. In the corresponding graph in the right part of Fig. 2, a **vertical line is drawn to separate subset 1 carriers from subset 2 carriers**. Subset 1 is constituted by carriers f11, f1, f2, f10, f3, f9 and f8, whilst subset 2 contains carriers f4, f7, f6 and f5." *Id.* at 6:33-37, Fig. 2. Therefore, in this example, the first plurality of carriers is defined as subset 1 and the second plurality of carriers is defined as subset 2.

496. Peeters further discloses equalization of the data element allocations within each group. *Id.* at 7:11. In order to maximize the minimum SNR within the first group of carriers, data elements of the first group are removed from carriers of subset 1 having a lower SNR margin and allocated to other carriers of subset 1 that have a higher SNR margin. *Id.* at 7:4-19. Once the data element distribution is performed, an optimal data bit allocation is now obtained, i.e., an allocation is found with maximal minimum SNR margins. *Id.* at 7:26-32.

497. A person of ordinary skill in the art would have understood that the system of Peeters describes bit allocation wherein a first plurality of carriers will have at least a first SNR margin and receive at least a first plurality of bits based on the first SNR margin logic.

498. Thus, Peeters discloses claim 16.b.

f. <u>Claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier"</u>

499. Peeters discloses claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier":

> To assign subsets of carriers to groups of data elements, all carriers are fictively arranged in increasing order or decreasing order of the predetermined carrier criterion (e.g. in increasing order of sensitivity of the carrier for burst errors). A first subset of e.g. 4 carriers is then associated with a first group of data elements, a second subset of e.g. **7 carriers is associated with a second group of data elements** having e.g. lower noise 20 compensation requirements than the first

> group of data elements, and so on. Once having allocated the data elements, the fourth carrier of the first subset however may be partially unoccupied by data elements of the first group and there-fore can be used as a mixed carrier, to which also data elements of the second group are allocated. By extrapolation of the above example, it is seen that for N groups of data elements, a maximum amount of N-1 mixed carriers is thus allowed

Id. at 3:16-24.

500. As described in the passage above, Peeters also discloses claim 10.b, wherein this second subset of carriers *e.g.*, 7 carriers, is associated with a second group of data elements.

501. Figure 1 and Figure 2 and their associated text further disclose a first and a second plurality of carriers as demonstrated by the first plurality of carriers having only interleaved data and a second plurality of carriers having only fast data with:

> The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to **classify the data elements in 2 groups**: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to **burst error correction** for the data elements as well as to **acceptable latency**. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors.

Id. at 5:38-44.

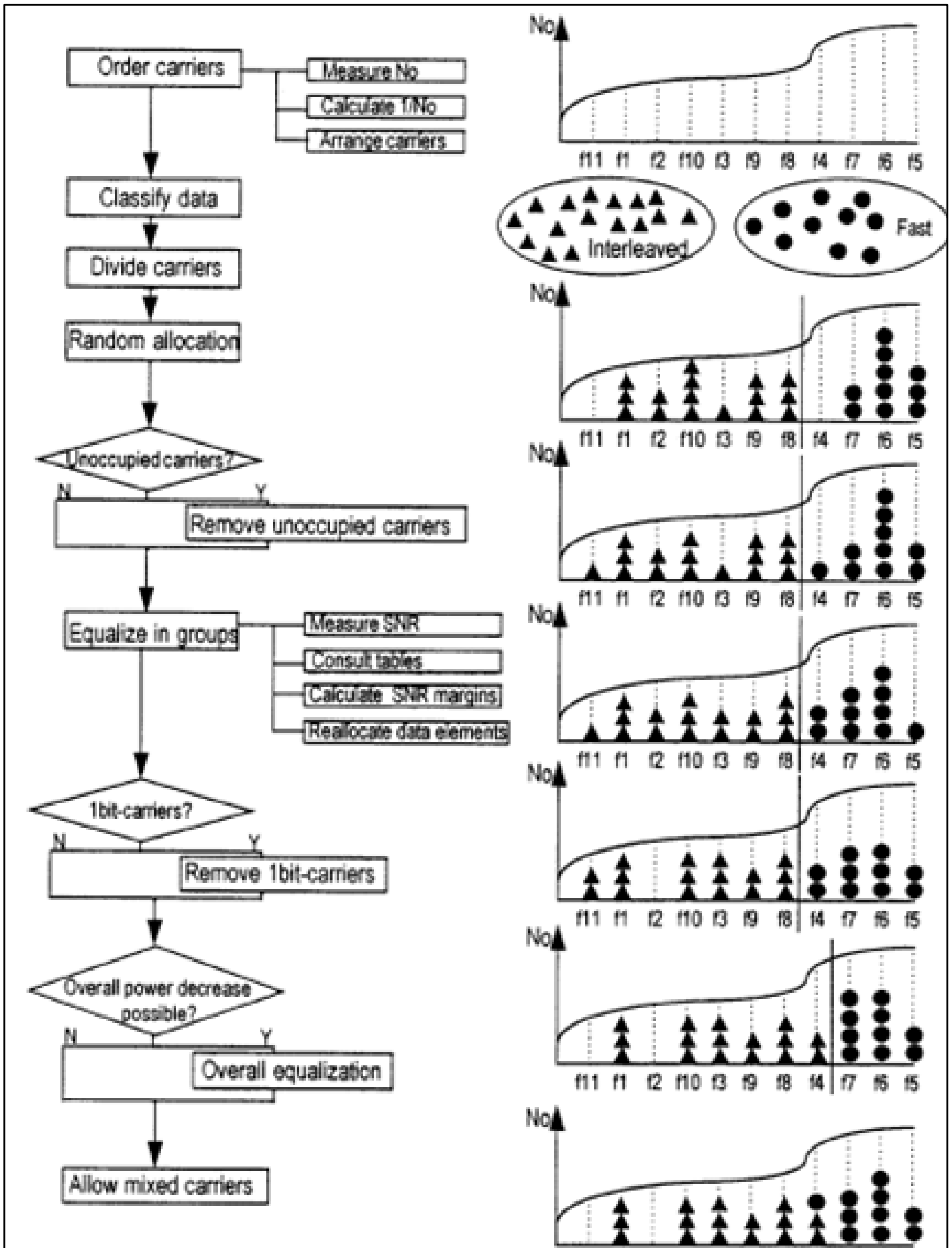


Fig. 2

Id. at Fig. 2.

502. Peeters further discloses an alternative implementation where the overhead data, as opposed to interleaved data, can constitute the first group of data elements while the user data, as opposed to fast data, can constitute the second group of data elements, wherein the user data is allocated to carriers different from the carriers occupied by the overhead data. *Id.* at 8:3-6.

503. Peeters further discloses that each "group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ... Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data." *Id.* at 2:33-38

504. Thus, Peeters discloses claim 16.c.

g. Claim 16.d "using a second SNR margin"

505. Peeters discloses claim 16.d "using a SNR margin."

506. As discussed above for element 16.c, incorporated herein, Peters discloses receiving a second plurality of carriers defined as subset 2 and subset 2 has a second plurality of bits based on the SNR margins for subset 2.

507. Thus, Peeters discloses claim 16.d.

h. Claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier"

508. Peeters discloses claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier."

509. To allocate a number of data elements to a set of carriers, Peeters discloses:

> To allocate a number of data elements to a set of carriers, the carriers are divided into N subsets of carriers according to a predetermined carrier criterion whilst the data elements are classified into N groups of data elements according to a predetermined data criterion, N being an integer.
>
> The predetermined data and carrier criterion have a relation on the basis of which the N subsets of carriers are associated one by one to the N groups of data elements. The data elements classified in such a group are then allowed to be modulated only on carriers which form part of the subset associated with this group.

> In addition, for each subset of carriers and related group of data elements the distribution is obtained by means of information from subset dependent 'required SNR (Signal Noise Ratio) per data element' -tables and previously carried out SNR measurements for each carrier.

Peeters at Abstract.

510. Peeters further discloses that each "group of data elements becomes modulated on a subset of carriers, these carriers being selected out of the full available set of carriers in accordance with another specific criterion, called a predetermined carrier criterion, e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, …. Based on the relation between **data and carrier criteria, the N groups of data elements** are linked one by one to the **N subsets of carriers**. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data." *Id.* at 2:33-38 (emphasis added).

511. At least the passages included above, show that Peeters discloses "N" groups of data elements are linked to "N" subsets of carriers, where N is an integer. With N = 3, Peeters discloses that there will be 3 different subsets of data grouped together based on each group's required SNR margin, 3 subsets of bit loading, and these 3 subsets of data will be linked to 3 different subsets of carriers. For this claim and specifically this element, the subset 1 and subset 3 carriers comprise the required "first carrier" and subset 2 would be the required "second carrier."

512. Therefore, Peeters discloses claim 16.e.

i. <u>Claim 16.f "using a third SNR margin"</u>

513. Peeters discloses claim 16.f "using a third SNR margin."

514. As described above for element 16.e and incorporated here, Peeters discloses three subsets of data based on three different SNR margins. Therefore, subset 3 would use a third SNR margin.

515. Peeters describes performing the calculations for **each carrier** using the measured SNR and the SNR margin with:

> These SNR margins are first calculated for each carrier in subset 1 **by subtracting the requested SNR from the SNR value measured on each of these carriers.** Carrier f1 for example carries 3 data bits in step 4. The SNR measured on f1 equals 22 dB whilst the required SNR allowing f1 to carry 3 data bits is equal to 20 dB. **As a result, the SNR margin for f1 equals 2 dB. The SNR margins similarly calculated for f2, f10, f3, f9 and f8 are equal to 0 dB, -1 dB, 7 dB, -1 dB and 2 dB respectively**. Since the minimum overall SNR margin equals the overall power decrease that can be performed, data elements are removed from a carrier to an unoccupied carrier in such a way that the minimum SNR margin increases as much as possible. Two carriers, f10 and f9 have an SNR margin of -1 dB. Since 4 data bits are allocated to f10 and 3 data bits are assigned to f9, f10 is more noise sensitive than f9. Therefore, a data bit is removed from f10 to f11. When the same procedure is applied to the second group of fast data elements in Fig. 2, the constellation drawn for step 4 changes into the constellation drawn for step 5.

Id. at 6:59-7:10.

516. Thus, Peeters discloses claim 16.f.

j. <u>Claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,"</u>

517. Peeters discloses claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier."

518. The Court has construed "SNR margin" as "a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

519. Peeters meets the Court's definition for SNR margin. For the SNR required to maintain a specified BER, Peeters discloses:

> Obviously, this is equal to measuring for each carrier frequency **the signal noise ratio (SNR) provided** that the signal power during this measurement equals 1 power unit. As is described on lines 21-24 of column 11 of the above mentioned US Patent, **the equivalent noise components are used in combination with the signal noise ratios necessary for transmission of the data elements with a given maximum bit error rate (BER)** to calculate therefrom the required transmission power levels, marginal required power levels for each carrier frequency and data element allocation.
>
> As stated on lines 26-27 of column 11 of US Patent 4,679,227, **these signal noise ratios** necessary for transmission of the data elements **are well known in the art**, and are found in a table which is called a 'required SNR per data element'-table in the present patent application. The data elements in the known method are then allocated one by one to the carriers requiring the lowest power cost to increase the constellation complexity. **In this way, the known method and modem provide a data element allocation to compensate for equivalent noise and to maximize the overall data transmission rate**. The known method and modem however treat all data elements in an identical way.

Peeters at 2:11-22.

520. For the SNR margin, Peeters discloses an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link. This extra SNR requirement is based on e.g., the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, with at least:

> In communication networks transporting data elements for different applications and services, the requirements for noise compensation, bit error rate, data transmission rate, bandwidth and so on, may depend on the type of application or service. Several types of data, each of which characterized by its own requirements and specifications, can thus be distinguished.
>
> An object of the present invention is to provide a method and equipment of the above known type but **which take into account data depending requirements for noise compensation, transmission rate and so on**, and **wherein data element allocation and transmission for each type of data are thus tuned to its own specifications.**
>
> According to the invention, this object is achieved in the method, mapping unit and modulator described in claims so 1, 13 and 14 respectively. Indeed, in the method described in claim 1, data elements are, according to a predetermined data criterion, e.g. the maximum allowable bit error rate, the required bandwidth, the required data transmission rate, the required compensation for noise, the required compensation for burst errors, ..., or a combination thereof, classified into N

> groups of data elements. Each group of data elements becomes modulated on a subset of carriers, **these carriers being selected out of the full available set of carriers in accordance with another specific criterion**, called a **predetermined carrier criterion**, e.g. **the sensitivity of a carrier frequency for noise, the sensitivity of a carrier frequency for burst errors, ...** Based on the relation between data and carrier criteria, the N groups of data elements are linked one by one to the N subsets of carriers. In this way, the carrier specific properties are tuned in to the requirements for transmission of specific groups of data.
>
> In addition, **by using signal noise ratio measurements in combination with information from a 'required SNR per data element'-table**, a distribution of data elements requiring the lowest overall power transmission is found in a similar way as described in the earlier cited US Patent, **noticing that each group of data elements in the present method is related to its own 'required SNR per data element'-table** which renders the allocation method more accurate.
>
> A further feature of the present data allocation method is that in a particular first implementation thereof, **the predetermined data criterion is equal to service dependent required compensation for occasional noise increase**. Telephone service for example will have lower requirements with respect to protection against occasional noise increase than telebanking service wherein all data have to be transmitted faultless. The **predetermined carrier criterion** in this first implementation **is defined as the sensitivity of a carrier for such occasional noise increase.**

Id. at 2:26-47.

521. The above passages describe that an SNR margin is established for each subset of data and all the SNR margins are set to not adversely affect the BER requirements for the type of data in each subset. Therefore, when N = 3, Peeters defines a first, second and third SNR margin based on the type of data that is to be transferred for each subset and each SNR margin is based on the BER requirements for the type of data in the subset. Thus, Peeters discloses a first SNR margin based on the BER for the type of data in subset 1.

522. Thus, Peeters discloses claim 16.g.

k. **<u>Claim 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an</u>**

<u>increase in the bit error rate (BER) associated with the second carrier,”</u>

523. Peeters discloses claim 16.h “wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier.”

524. As discussed above in 16.g, Peeters discloses an extra SNR requirement (the second SNR Margin) assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link. Peeters also discloses a second SNR margin based on the BER for the type of data in subset 2.

525. Thus, Peeters discloses claim 16.h.

l. <u>Claim 16.i “wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,”</u>

526. Peeters discloses claim 16.i “wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier.”

527. As discussed above in 16.g, Peeters discloses an extra SNR requirement (the third SNR Margin) assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link. Peeters also discloses a third SNR margin based on the BER for the type of data in subset 3. As described above in element 16.e, the subset 1 and subset 3 carriers comprise the required “first carrier.” Thus, the Peeters discloses claim 16.i.

528. Thus, Peeters discloses claim 16.i.

m. <u>Claim 16.j “wherein the first SNR margin is different than the second SNR margin,”</u>

529. Peeters discloses claim 16.j “wherein the first SNR margin is different than the second SNR margin.”

530. As discussed above for at least element 10.a, incorporated herein, Peeters discloses that the subset 1 carriers, i.e., for the interleaved data group, will have a different SNR margin than the subset 2 carriers, i.e., the fast data group because each type of data has different SNR margin requirements. These two types of data and their unique requirements are described with at least:

> The mapper MAP of Fig. 1 for the description in the following paragraphs is supposed to classify the data elements in 2 groups: a group of interleaved data and a group of fast data. The classification is performed based upon the requirements with respect to burst error correction for the data elements as well as to acceptable latency. Indeed, data elements which need to be protected against burst errors will be interleaved and therefore will be allocated to carriers with a high sensitivity for burst errors since for these carriers, protection by interleaving is provided. On the contrary, data such as telephone speech data, which have lower requirements with respect to protection against burst errors but are delay sensitive, will not be interleaved but can be allocated to carriers which are less sensitive for burst errors.

Id. at 5:38-44.

531. Peeters discloses that the first SNR margin is different than the second SNR margin with at least Figure 4 and its associated text. In the annotated Figure 4 shown below, the table on the left is for the subset 1 carriers and the table on the right is for the subset 2 carriers. *Id.* at 6:57-58. The "Requested SNR (dB)" shown in the right-hand heading of each table is the "SNR margin" as construed by the Court. *Id.* at 6:59-7:2 ("These SNR margins are first calculated for each carrier in subset 1 by subtracting the **requested SNR** from the **SNR value measured** on each of these carriers."). Figure 5, also shown below, shows the measured SNR values. *Id.* at 6:58-59. The table on the left lists 5 different values for the "first SNR margin." *Id.* at Fig. 4. The table on the right lists 5 different values for the "second SNR margin." *Id.* A comparison of the values listed for the first and second SNR margins shows that all the values listed for the first SNR margin are different than all the values listed for the second SNR margin. Specifically, Subset 2 does not include the values 16, 20, 23 or 25.

532. Alternatively, if the Court determines that the SNR margin for the first plurality of carriers needs to be the same value and the SNR margin for the second plurality of carriers also needs to be the same value but different a different value than the first SNR, Peeters also discloses this configuration with the first two carriers listed for subset 1 and subset 2. Specifically, the first plurality of carriers in subset 1 would have a SNR margin of 16 and the second plurality of carriers in subset 2 would have a SNR margin of 15. Therefore, 16 is a different value than 15.

Number of bits allocated	Requested SNR (dB)
1	16
2	16
3	20
4	23
5	25

Subset 1

Number of bits allocated	Requested SNR (dB)
1	15
2	15
3	21
4	24
5	27

Subset 2

Fig. 4

Id. at Fig. 4 (annotated).

Carrier	Measured SNR (dB)
f11	17
f1	22
f2	16
f10	22
f3	23
f9	19
f8	22
f4	23
f7	26
f6	26
f5	18

Fig. 5

Id. at Fig. 5 (annotated).

533. Thus, Peeters discloses claim 16.j.

n. Claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"

534. Peeters discloses claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"

535. As discussed above for at least elements 16.a-16.f, incorporated herein, subset 1 and subset 3 will have different types of data and will also have different SNR margins that are set based on the type of data. Because the type of data in subset 1 is different than the type of data in subset 3, each subset will have a different SNR margin. Therefore, the first SNR margin will be different than the third SNR margin.

536. Thus, Peeters discloses claim 16.k.

o. Claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

537. Peeters discloses claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

538. As discussed above for at least elements 16.a-16.f, incorporated herein, subset 1, subset 2 and subset 3 have different SNR margins because they are based on different types of data with at least different BERs. Therefore, each subset will have different bit loading requirements. Subset 1 is the "first plurality of bits," subset 2 is the "second plurality of bits" and subset 3 is the "third plurality of bits". Therefore, Peeters discloses that the first plurality of bits and the second plurality of bits is different from one another.

539. Thus, Peeters discloses claim 16.l.

540. Therefore, Peeters discloses all of claim 16.

2. U.S. Patent No. 6,205,410 to Cai ("Cai") in View of Peeters

541. Cai in view of Peeters renders obvious each element of claim 16 of the '988 Patent.

542. I provided a brief description of Peeters above. *See supra* §XII.A.1.a, which I incorporate by reference here. I also provide a brief description of Cai above (*see supra* section XII.A.2.a). I incorporate that discussion by reference here.

a. <u>Claim 16</u>

543. Claim 16 of the '988 Patent is rendered obvious by Cai in view of Peeters.

b. <u>Motivation to Combine Teachings of Cai with Teachings of Peeters</u>

544. A person of ordinary skill in the art would have been motivated to combine the disclosure of Cai with Peeters because they both describe methods to obtain optimal data bit allocation/SNR Margins. *See e.g.*, Peeters at 7:26-32; Cai at 4:31-35.

545. A person of ordinary skill in the art would have understood that both Cai and Peeters techniques are designed to work with DMT systems. *See* Peeters at 7:54-57, 3:47-58, claim 11; Cai at Abstract. Because of this, one of ordinary skill in the art would have considered these references together.

546. Cai's objective is to optimize the margin of each subcarrier used by a DMT system in order to provide an optimum bit rate. *See*, *e.g.*, Cai at Abstract, 1:51-62, 9:46-49. Cai is exactly the type of reference a skilled artisan would have sought because Cai describes how to determine the optimum margin for each subchannel of a DMT system. Specifically, Cai describes a DMT system in which each subcarrier potentially suffers from a different variation in SNR. *Id.* at 3:7-13. The margin used for each subchannel is proportional to its SNR variation (the difference between the maximum observed SNR and the minimum observed SNR), so that a subchannel with a large swing in its SNR over time is used with a larger margin than a subchannel with a small swing in its SNR. *Id.* Cai discloses that "the optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while

ensuring a desired bit error rate which is, for example, 10-7." *Id*. at 9:46-49. Cai describes several alternatives for SNR variation logic that "is executed at predetermined times to ascertain the variation of the signal-to-noise ratio for each individual DMT channel from which the margin for each channel is calculated." *Id.* at 5:5-8; *see also, e.g., id*. at 6:61-9:49.

547. The primary difference between Peeters and Cai is that Peeters suggests dividing subsets of carriers based on the type of data element grouping. *See* Peeters at 6:24-50. Although Cai is directed towards optimizing SNR margins on each carrier, Cai discloses that the SNR can be the same on more than one carrier, in addition to being different than the other carriers. *See e.g.,* Cai at Fig. 2, 3:7-13, 9:45-48. One of ordinary skill in the art would have understood that the carriers in Cai's DMT system could be divided into subsets of carriers where each subset would have the same SNR margin. A person of ordinary skill in the art would have also found this modification trivial, particularly because Peeters discloses that different margins can be used for different subchannels, and Cai discloses that the SNR variation logic can determine the optimum margin for each subchannel. Thus, a person of ordinary skill in the art would have had reasonable expectations of success in combining the teachings of Peeters' with Cai's technique of optimizing the SNR margin on each carrier.

c. Claim 16.pre "An apparatus comprising: a multicarrier communications transceiver"

548. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Cai in view of Peeters discloses claim 16.pre "An apparatus comprising: a multicarrier communications transceiver."

549. As discussed above, Cai describes a DMT multicarrier transceiver that modulates and demodulates a plurality of bits. Cai at 1:12-13 ("this invention relates to the field of discrete multi-tone (DMT) data communication"), 1:19-22 ("In data communications using discrete

multitone (DMT) technology, a serial data bit stream to be communicated is distributed among multiple channels and transmitted in parallel from a transmitting modem to a receiving modem."). Cai further describes a system and method which establishes an optimum margin for each channel in a discrete multi-tone DMT transceiver. *Id.* at Abstract.

550. Cai also discloses a discrete multitone (DMT) data link which "communicates across a communications channel" and is understood that the "functionality of the transmitter 103 and receiver 106 are generally combined in a single DMT modem so that it may transmit and receive data communication to and from other modems." *Id.* at 3:14-24; *see also id.* at 1:67-2:13, 4:51-54.

551. Thus, Cai discloses the preamble of claim 16, to the extent it is limiting.

552. I explained above (*see supra*, § XII.B.1.c) that Peeters also discloses this element. I incorporate that explanation by reference here. Accordingly, Cai in view of Peeters discloses claim 16.pre to the extent it tis limiting.

d. <u>Claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier"</u>

553. Cai in view of Peeters discloses 16.a "operable to demodulate for reception a first plurality of bits from a first carrier."

554. Cai discloses a system with "bit loading logic th[at] determines a bit loading configuration based upon the variation in the Signal to-noise ratio ascertained by the SNR variation logic." *Id.* at 2:5-9. Cai discloses three SNR variation logics that each achieve "precise bit allocation and tone scaling . . . based upon the SNR estimate and the optimum margin estimate determined from the SNR variation in the bit loading block 156 at the startup of data communication." *Id.* at 4:31-35, 2:14-21. The "actual distribution of the data input 113 among

the multiple DMT channels by the bit allocation block 116 is performed pursuant to the bit allocation table 116." *Id.* at 4:36-39.

555. Cai discloses a "receiver 106 [which] … receives the DMT signal from the inverse fast Fourier transform block 126 at the time domain equalizer block 129." *Id.* at 3:33-35. Cai further discloses "a serial data stream enters the bit allocation block 116 where the serial data is distributed among multiple DMT channels, each DMT channel corresponding to an individual quadrature amplitude modulation block." *Id.* at 3:51-56. These QAM blocks "generally produce a demodulated tone which is then scaled based upon a desired signal-to-noise ratio for each individual DMT channel in the tone scaling block 123 according to the tone scaling table 169." *Id.* at 3:61-64. "The multiple DMT channels are then combined by the inverse fast fourier transform block 126 and transmitted across the channel 109 to the time domain equalizer block 129 of the receiver 106." *Id.* at 3:65-4:2. Cai further discloses that the "overall margin is an average of the margins for each channel in the timed domain." *Id.* at 5:20-22. Cai therefore discloses a system with a first plurality of bits and a first carrier.

556. Thus, Cai discloses claim 16.a.

557. I explained above (*see supra*, § XII.B.1.d) that Peeters also discloses this element. I incorporate that explanation by reference here. Accordingly, Cai in view of Peeters discloses claim 16.a.

e. <u>Claim 16.b "using a first Signal to Noise Ratio (SNR) margin"</u>

558. Cai in view of Peeters discloses 16.b "using a first Signal to Noise Ratio (SNR) margin."

559. Cai discloses a system with a plurality of carriers, or channels, wherein the "SNR margins employed vary from channel to channel, depending upon the potential SNR variation experienced during the connection." *Id.* at 3:3-8. "For example a large margin 63 is used in

channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. Figure 2 shows a plurality of carriers, reaching having their own SNR margin:

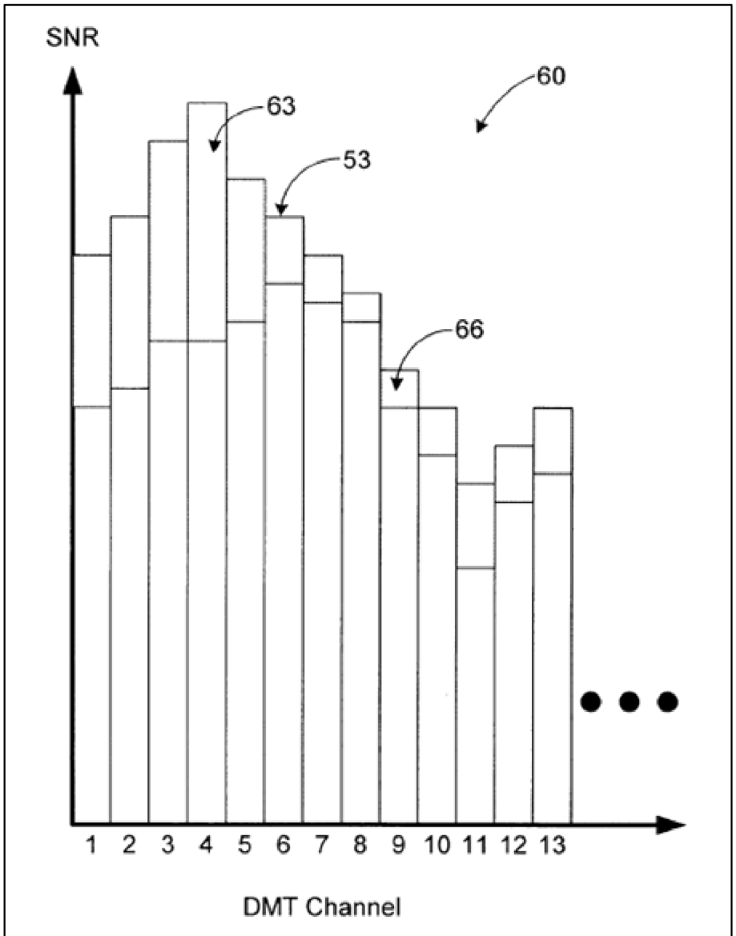


Fig. 2

Id. at Fig. 2.

560. A person of ordinary skill in the art would have understood that Cai discloses a first plurality of carriers all having the same average SNR margin that is different than a second plurality of carriers all having a different average SNR margin. For instance, a person of ordinary skill in the art could understand that Cai discloses a system wherein channels, or carriers, 1, 2, and 3 of FIG. 2 comprise a first plurality of carriers having the same average SNR margin, and

channels, or carriers, 6, 12, and 13 comprise a second plurality of carriers having the same average SNR margin.

561. Thus, Cai discloses claim 16.b.

562. I explained above (*see supra*, § XII.B.1.e) that Peeters also discloses this element. I incorporate that explanation by reference here. Accordingly, Cai in view of Peeters discloses claim 16.b.

f. **Claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier"**

563. Cai in view of Peeters discloses 16.c "and to demodulate for reception a second plurality of bits from a second carrier."

564. As discussed above, Cai discloses a system with "bit loading logic th[at] determines a bit loading configuration based upon the variation in the Signal to-noise ratio ascertained by the SNR variation logic." *Id.* at 2:5-9. Cai discloses three SNR variation logics that each achieve "precise bit allocation and tone scaling . . . based upon the SNR estimate and the optimum margin estimate determined from the SNR variation in the bit loading block 156 at the startup of data communication." *Id.* at 4:31-35, 2:14-21. The "actual distribution of the data input 113 among the multiple DMT channels by the bit allocation block 116 is performed pursuant to the bit allocation table 116." *Id.* at 4:36-39.

565. Cai discloses a "receiver 106 [which] … receives the DMT signal from the inverse fast Fourier transform block 126 at the time domain equalizer block 129." *Id.* at 3:33-35. Cai further discloses "a serial data stream enters the bit allocation block 116 where the serial data is distributed among multiple DMT channels, each DMT channel corresponding to an individual quadrature amplitude modulation block." *Id.* at 3:51-56. These QAM blocks "generally produce a demodulated tone which is then scaled based upon a desired signal-to-noise ratio for each

individual DMT channel in the tone scaling block 123 according to the tone scaling table 169." *Id.* at 3:61-64. "The multiple DMT channels are then combined by the inverse fast fourier transform block 126 and transmitted across the channel 109 to the time domain equalizer block 129 of the receiver 106." *Id.* at 3:65-4:2. Cai further discloses that the "overall margin is an average of the margins for each channel in the timed domain." *Id.* at 5:20-22. Cai therefore discloses a system with a second plurality of bits and a second carrier.

566. Thus, Cai discloses claim 16.c.

567. I explained above (*see supra*, § XII.B.1.f) that Peeters also discloses this element. I incorporate that explanation by reference here. Accordingly, Cai in view of Peeters discloses claim 16.c.

g. Claim 16.d "using a second SNR margin"

568. Cai in view of Peeters discloses 16.d "using a second SNR margin."

569. Cai discloses a system with a plurality of carriers, or channels, wherein the "SNR margins employed vary from channel to channel, depending upon the potential SNR variation experienced during the connection." *Id.* at 3:3-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. Figure 2 shows a plurality of carriers, reaching having their own SNR margin:

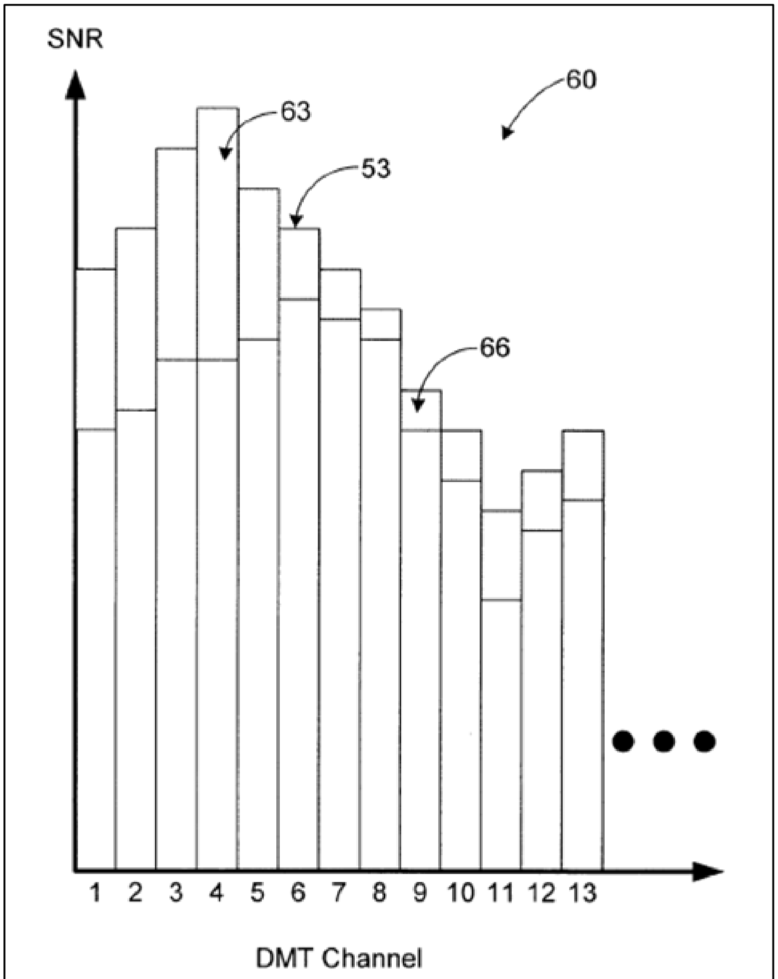


Fig. 2

Id. at Fig. 2.

570. A person of ordinary skill in the art would have understood that Cai discloses a first plurality of carriers all having the same average SNR margin that is different than a second plurality of carriers all having a different average SNR margin. For instance, a person of ordinary skill in the art could understand that Cai discloses a system wherein channels, or carriers, 1, 2, and 3 of Figure 2 comprise a first plurality of carriers having the same average SNR margin, and channels, or carriers, 6, 12, and 13 comprise a second plurality of carriers having the same average SNR margin.

571. Thus, Cai discloses claim 16.d.

572. I explained above (*see supra*, § XII.B.1.g) that Peeters also discloses this element. I incorporate that explanation by reference here. Accordingly, Cai in view of Peeters discloses claim 16.d.

h. <u>Claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier"</u>

573. Cai in view of Peeters discloses 16.e "and to demodulate for reception a third plurality of bits from the first carrier."

574. As discussed above for at least Peeters element 16.e, incorporated herein, Peeters discloses this element. As discussed above, Cai discloses using different SNR margins for different carriers that results in different bit loading scenarios for each carrier that has a different SNR margin.

575. As also discussed above for at least Peeters element 16.e, the subset 1 and subset 3 carriers comprise the required "first carrier" and subset 2 carriers comprise the second carrier.

576. One of ordinary skill in the art would have been motivated to combine Peeters with Cai because both references are in regard to setting a SNR margin on the channels of a DMT system and Peeters discloses a method for communicating different types of data with different SNR margins so if a person of ordinary skill wanted to understand how to communicate three different types of data over a DMT system, Peeters subsets would be one feasible method to do so.

577. Thus, Cai in view of Peeters discloses claim 16.e.

i. <u>Claim 16.f "using a third SNR margin"</u>

578. Cai in view of Peeters discloses 16.f "using a third SNR margin."

579. As discussed for element 16.e above, Peeters discloses three different types of data and three different SNR margins assigned to each type of data (subset 1, subset 2 and subset 3). Therefore, Cai in view of Peeters discloses a "third SNR margin."

580. A person of ordinary skill in the art would be motivated to combine Peeters with Cai for the same reasons stated above for element 16.e.

581. I explained above (*see supra*, § XII.B.1.i) that Peeters also discloses this element. I incorporate that explanation by reference here.

582. Thus, Cai in view of Peeters discloses claim 16.f.

j. Claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,"

583. Cai discloses 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise **without an increase in the bit error rate (BER)** associated with the first carrier." As a result of the SNR logic, the "optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while ensuring a desired bit error rate which is, for example, 10^{-7}." *Id.* at 9:45-48. The optimum margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13.

584. The first SNR margin for the first plurality of carriers therefore specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier.

585. Thus, Cai discloses claim 16.g.

586. I explained above (*see supra*, § XII.B.1.j) that Peeters also discloses this element. I incorporate that explanation by reference here.

587. Accordingly, Cai in view of Peeters discloses claim 16.g.

k. Claim 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier,"

588. Cai discloses 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier."

589. As a result of the SNR logic, the "optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while ensuring a desired bit error rate which is, for example, 10^{-7}." *Id.* at 9:45-48. The optimum margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13.

590. The second SNR margin for the second plurality of carriers therefore specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier.

591. Thus, Cai discloses claim 16.h.

592. I explained above (*see supra*, § XII.B.1.k) that Peeters also discloses this element. I incorporate that explanation by reference here.

593. Accordingly, Cai in view of Peeters discloses claim 16.h.

l. Claim 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,"

594. Cai in view of Peeters discloses 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier."

595. As a result of the SNR logic, the "optimum margins are calculated for each DMT channel, which in turn translates into an optimum bit rate for each DMT channel while ensuring a desired bit error rate which is, for example, 10^{-7}." *Id.* at 9:45-48. The optimum margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13.

596. The third SNR margin for the first plurality of carriers therefore specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the third carrier.

597. Thus, Cai discloses claim 16.i. I explained above (*see supra*, § XII.B.1.l) that Peeters also discloses this element. I incorporate that explanation by reference here.

598. Accordingly, Cai in view of Peeters discloses claim 16.i.

m. Claim 16.j "wherein the first SNR margin is different than the second SNR margin,"

599. Cai in view of Peeters discloses 16.j "wherein the first SNR margin is different than the second SNR margin."

600. Cai is directed toward a system where SNR margins vary from channel to channel. *Id.* at 3:7-8. "For example a large margin 63 is used in channel 4 whereas a small margin 66 is used for channel 9. The varying margins allow the DMT channels to be used with a maximum of efficiency, while ensuring a low bit error rate." *Id.* at 3:10-13. This is further evidenced in Figure 2:

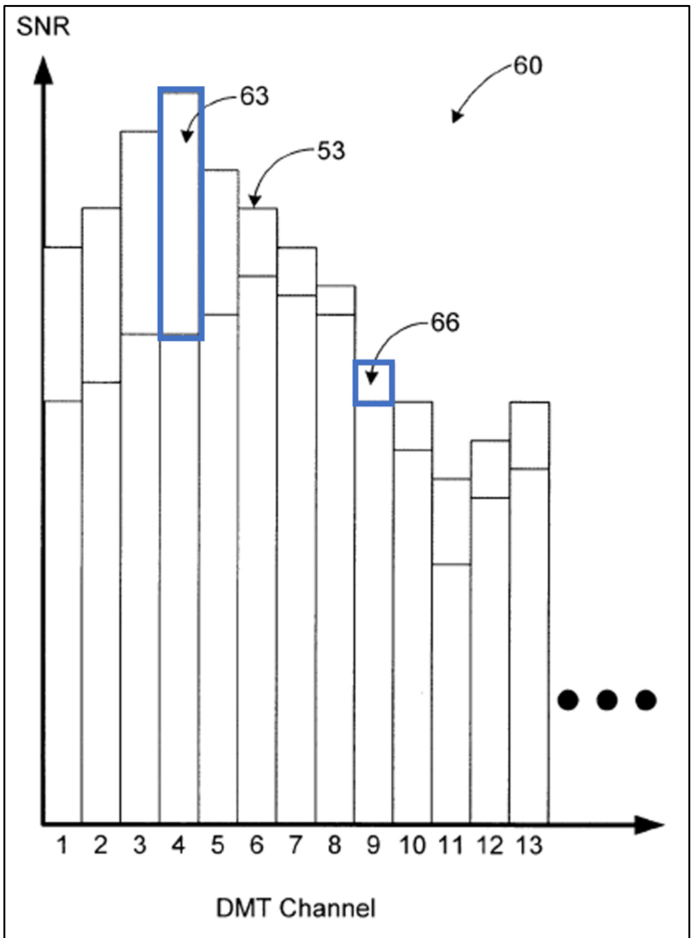


Fig. 2

Id. at Fig. 2 (annotated).

601. As discussed above, Cai discloses a system where a large (or higher) margin is used on one channel, and a small (or lower) margin is used on a different channel. *Id.* at 3:7-13, Fig. 2.

602. As discussed above for at least Peeters element 16.j, incorporated herein, Peeters discloses that the SNR margin is different for each subset. Thus, the SNR margin for subset 1, subset 2 and subset 3 are all different so, for this element, the first SNR margin is different than the second SNR margin.

603. Thus, Cai in view of Peeters discloses claim 16.j.

604. I explained above (*see supra*, § XII.B.1.m) that Peeters also discloses this element. I incorporate that explanation by reference here.

605. Accordingly, Cai in view of Peeters discloses claim 16.j.

n. <u>Claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"</u>

606. Cai discloses 16.k "wherein the first SNR margin is different than the third SNR margin, and."

607. As discussed above for Peeters element 16.j, incorporated herein, the SNR margin is different for subset 1, subset 2 and subset 3 in Peeters and the subset numbers correspond to the required "first, second and third SNR margins." Thus, the first SNR margin is different than the third SNR margin.

608. Thus, Cai in view of Peeters discloses claim 16.k.

o. <u>Claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."</u>

609. Cai in view of Peeters discloses 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

610. As discussed at least in Peeters element 16.l above, the plurality of bits is different for subset 1, subset 2 and subset 3 because each subset uses a different SNR margin based on the type of data assigned to the subset. Therefore, the plurality of bits in subset 1 (first) is different than the plurality of bits in subset 2 (second) and the plurality of bits in subset 3 (third) is different than subset 1 or subset 2.

611. Thus, Cai in view of Peeters discloses claim 16.l.

612. Therefore, Cai in view of Peeters discloses all of claim 16.

3. U.S. Patent No. 6,516,027 to Kapoor et al. ("Kapoor") In View of Peeters

613. Kapoor in view of Peeters renders obvious each element of claim 16 of the '988 Patent. I provided a brief description of Peeters above. *See supra* §XII.A.1.a, which I incorporate by reference here. I also provide a brief description of Kapoor above (*see supra* §XII.A.3.a). I incorporate that discussion by reference here.

a. Motivation to Combine Teachings of Kapoor With Teachings of Peeters

614. A person having ordinary skill in the art would have been motivated to combine the teachings of Kapoor with the teachings of Peeters as recited in claim 16 of the '988 patent and would have had a reasonable expectation of success in making the combination.

615. Both Kapoor and Peeters are directed to improving the performance of DMT systems. Kapoor's objective is to provide bit loading (i.e., the allocation of bits to subcarriers) techniques that improve on existing bit loading algorithms. *See, e.g.,* Kapoor at Abstract, 3:7-4:21. Peeters is directed to allocating data elements to sets of carriers. Peeters at 2:3-5. Peeters is used in ADSL applications but can also be implemented in other transmission systems. *Id.* at 7:54-57, 3:47-58, claim 11.

616. The disclosures of Peeters are complementary to those of Kapoor, and it would have been obvious to a person having ordinary skill in the art to combine them. For example, Kapoor states that prior art bit loading algorithms "do not support a bit allocation method which allows different subchannels to operate at different bit error rates or margins," but that it would be "desirable to have a method which can allocate bits to subchannels based on a desired bit error rate, and further to be able to allow subchannels to operate at different bit error rates." Kapoor at 4:8-10, 17-21. Kapoor describes that its techniques allow different subchannels to "have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains. . . ." *Id.* at 8:39-42. Kapoor thus discloses that different margins can be used on different subchannels. But Kapoor does not describe in detail how to determine what the different margins on the different subchannels should be. Accordingly, a person having ordinary skill in the art would have sought references addressing how to determine what the different margins on different subchannels should be.

617. A person having ordinary skill in the art would thus have been motivated to add the method of Peeters to the communication devices of Kapoor, and would have found it trivial to do so. More specifically, Kapoor describes reducing the measured SNR of each subchannel by the difference between the margin and the coding gain (i.e., by the quantity γ_margin-γ_coding), and then determining the bit allocation and gain scaling values using the resulting reduced measured SNR values. *See, e.g.,* Kapoor at 7:43-10:46. Based on the teachings of Peeters, a person having ordinary skill in the art would have been motivated to use Peeters' method of grouping subsets of carriers together and assigning certain data to the respective subsets of carriers. *See e.g.,* Peeters at 3:16-24. A skilled artisan would have found this modification

trivial, particularly because Kapoor discloses that different margins can be used for different subchannels, and Peeters discloses allocating data elements to different sets of carriers.

618. Thus, a person having ordinary skill in the art would have had a strong expectation of success in combining Peeter's teachings (e.g., allocating data elements to different sets of carriers) with Kapoor's bit allocation procedures that allow the noise margin, error probability, and coding gain to vary from subchannel to subchannel.

b. Claim 16

619. Claim 16 of the '988 Patent is rendered obvious by Kapoor in view of Peeters.

c. Claim 16.pre "An apparatus comprising: a multicarrier communications transceiver"

620. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Kapoor in view of Peeters discloses claim 16.pre "An apparatus comprising: a multicarrier communications transceiver."

621. Kapoor details a method and apparatus for discrete multitone communication bit allocation. Kapoor at Title. Kapoor relates to a discrete multitone modulation ("DMT") communication system. "The present invention relates to data communications, specifically to an apparatus and method for allocating bits among carrier tone subchannels (bins) in a discrete multitone modulation (DMT) communication system." *Id.* at 1:7-11.

622. Kapoor also discusses SNR gaps that depend on the modulation and coding used in a transmitter. "The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure

that the received SNR in the i subchannel corresponds to bi bits in that Subchannel." *Id.* at 3:58-67.

623. Moreover, the method and apparatus operates over a computer, that connects with a DSL network interface and a DTE interface. "Data terminal equipment interface 16 and DSL network interface 20 are used **to send and receive data to and from data terminal equipment and a DSL network**, respectively." *Id.* at 6:13-16; *Id.* at Figure 2.

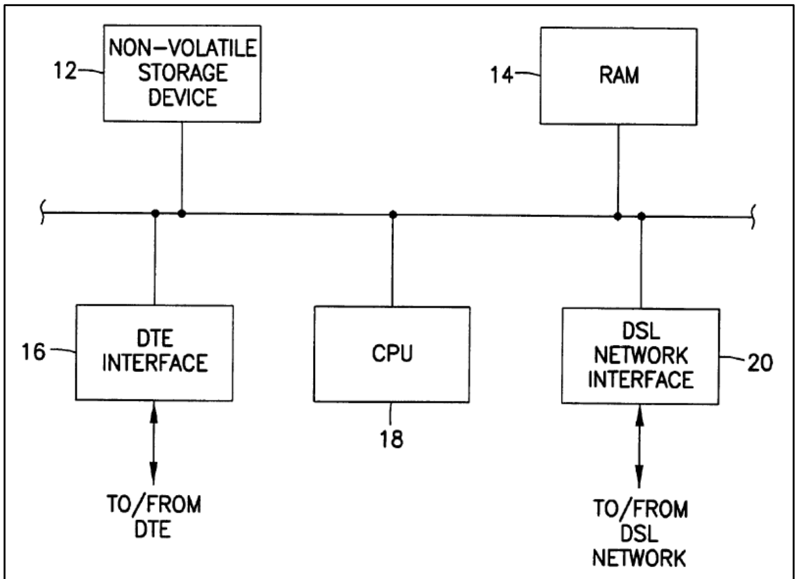


Fig. 2

Id. at Fig. 2.

624. Thus, Kapoor discloses the preamble of claim 16, to the extent it is limiting.

625. I explained above (*see supra*, §XII.B.1.c) that Peeters also discloses the preamble of claim 16, to the extent it is limiting. I incorporate that explanation by reference here.

626. Thus, Kapoor in view of Peeters discloses 16.pre.

d. <u>Claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier"</u>

627. Kapoor in view of Peeters renders obvious 16.a "operable to demodulate for reception a first plurality of bits from a first carrier."

628. Kapoor discloses receiving a multicarrier symbol. "Subsequent DMT multicarrier modulation equipment made use of digital signal processing techniques including Fast Fourier Transforms and Inverse Fast Fourier Transforms. Digital signal processing allowed a single DMT communication device to be used to modulate all subchannels, thereby improving reliability and lowering the cost of communications." *Id.* at 2:7-13.

629. Kapoor discloses a plurality of carriers. "A preferred approach is to load each subchannel based on the individual transmission characteristics of that subchannel. Better subchannels, should carry more information than poorer quality subchannels. This allows an efficient use of the communication channel resources." *Id.* at 2:16-20. The indication of multiple subchannels means there are a plurality of carriers. The underlying invention in Kapoor allows for SNR ratios are measured for each plurality of subchannels in a communication system, which is consistent with having a plurality of channels with different SNR ratios as disclosed in the '354 Patent.

630. In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a corresponding plurality of respective bit values, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to noise ratio values also correspond to the plurality of respective bit values. It is another object of the present invention to provide a method of allocating bits to a plurality of transmission subchannels in a communication system, in which a measuring step measures a signal-to-noise ratio for each of the plurality of transmission subchannels. An adjusting step adjusts the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain. *Id.* at 4:32-46.

631. Moreover, different pluralities of carriers are grouped in Kapoor via the different subchannels which each group having different bit allocation values. "Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:36-42.

632. Kapoor discloses at least two pluralities of carriers in Fig. 5 shown below and its associated text. Specifically, Figure 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

633. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated).

634. Kapoor discloses receiving a multicarrier symbol. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16.

635. Thus, Kapoor discloses claim 16.a.

636. I explained above (*see supra*, §XII.B.1.d) that Peeters also discloses this element. I incorporate that explanation by reference here. Thus, Kapoor in view of Peeters discloses 16.a.

e. Claim 16.b "using a first Signal to Noise Ratio (SNR) margin"

637. Kapoor in view of Peeters renders obvious 16.b that a transceiver is operable to demodulate for reception the first plurality of bits from the first carrier "using a first Signal to Noise Ratio (SNR) margin."

638. The Court has construed "SNR margin" as "a parameter used in determining the number of bits allocated to each of a plurality of carriers, where the value of the parameter specifies an extra SNR requirement assigned per carrier in addition to the SNR required to maintain a specified bit error rate (BER) for the communication link at a specified bit allocation." Claim Construction Memorandum and Order (Dkt. No. 169) at 116.

639. Kapoor meets the Court's definition for SNR Margin. Kapoor describes the "SNR gap" or "margin" as "the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap." Kapoor at 2:21-27.

640. Further, the "SNR gap is a function of a chosen probability of transmission error and the modulation and coding techniques. The SNR gap measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel. The SNR gap is often constant over a wide range of transmission rates which may be transmitted by the particular modulation coding technique. The channel capacity refers to the maximum data rate capable of being transmitted on a particular channel. The optimum line coding technique has a SNR gap of zero dB. Although such an optimum line code requires infinite decoding/encoding delay and is infinitely complex, it has become practical at typical Digital Subscriber Line (DSL) speeds to implement modulation methods to achieve SNR

gaps as low as 1-2 dB. Therefore, one factor to be considered during the bit allocation process is the transmission quality of each subchannel, in order to maximize the bit allocation for each subchannel." *Id.* at 2:21-45.

641. For the SNR required to maintain a specified BER, Kapoor discloses: "the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER)." *Id.* at 3:59-61. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

642. Kapoor further describes how the SNR margin is used in connection with bit allocation:

> The processing unit controls functions which **measure a signal-to-noise ratio** for each of the plurality of transmission subchannels, **adjust the measured signal-to noise ratio** in accordance with an **SNR-margin** and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, **the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values**, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory.

Id. at 5:1-12.

643. These SNR margins have a corresponding bit value as disclosed in Kapoor. "In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a **corresponding plurality of respective bit values**, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to-noise ratio values also correspond to the plurality of respective bit values." *Id.* at 4:32-39.

644. Thus, Kapoor discloses claim16.b.

645. I explained above (*see supra*, §§XII.B.1.e), Peeters also discloses this element. I incorporate that explanation by reference here. Thus, Kapoor in view of Peeters discloses this 16.b.

f. Claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier"

646. Kapoor in view of Peeters renders obvious 16.c that the multicarrier communications transceiver is operable "to demodulate for reception a second plurality of bits from a second carrier."

647. Different pluralities of carriers are grouped in Kapoor via the different subchannels which each group having different bit allocation values. "Similarly, the process can be repeated to create a set of tables **for a different SNR gap** for a different line coding technique (step 30). Different subchannels therefore, **can each have bit allocation values calculated based on different margins**, different $P_e/2$ error rates, and different coding gains, **subject to the quantity of tables stored in the communication device 10**." *Id.* at 8:36-42.

648. Kapoor discloses at least two pluralities of carriers in Figure 5 shown below and its associated text. Specifically, Figure 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec

> columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of **10^{-7} and a bit allocation of 5 bits corresponds** to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of **10^{-8}** of 2.5516e + 02.

Id. at 8:20-24.

649. Thus, Kapoor discloses this claim 16.c.

650. I explained above (*see supra*, §§XII.B.1.f) that Peeters also discloses this element. I incorporate that explanation by reference here. Thus, Kapoor in view of Peeters discloses 16.c.

g. Claim 16.d "using a second SNR margin"

651. Kapoor in view of Peeters renders obvious 16.d that the multicarrier communications transceiver is operable to demodulate for reception the second plurality of bits from the second carrier "using a second SNR margin."

652. I incorporate by reference my analysis for claim elements 16.pre, 16.a, 16.b, and 16.c.

653. The plurality of subchannels in Kapoor show that the reference discloses that each of the subchannels (carriers) have a separate SNR margin and that each subchannel has a different bit allocation value.

654. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

655. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated).

656. The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission

subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory. *Id.* at 5:1-12.

657. A plurality is construed as meaning more than one, thus, there is a second plurality of bits on a second plurality of carriers which uses a second SNR margin.

658. Thus, Kapoor discloses this claim 16.d.

659. I explained above (*see supra*, § XII.B.1.g), Peeters also discloses this element. I incorporate that explanation by reference here. Thus, Kapoor in view of Peeters discloses 16.d.

h. Claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier"

660. Kapoor in view of Peeters renders obvious 16.e "and to demodulate for reception a third plurality of bits from the first carrier."

661. As also discussed above for at least Peeters element 16.e, the subset 1 and subset 3 carriers comprise the required "first carrier" and subset 2 carriers comprise the second carrier.

662. Kapoor discloses at least two pluralities of carriers in Fig. 5 shown below and its associated text. Specifically, Figure 5 shows two different tables for carrier bit allocation based on the target BER for the carrier. The top table provides the required SNR_{vec} and SNR_{maxvec} values for allocations of different bits based on a target BER of 10^{-7}. The bottom table provides the same information but for a target BER of 10^{-8}. Thus, the bottom table defines a first plurality of carriers with a first plurality of bits based on a more stringent BER. The top table defines a second plurality of carriers with a second plurality of bits based on a less stringent BER. Kapoor describes that the two highlighted rows below for a 5-bit allocation require different SNR margins with:

> For example, in the ANSI Tl.413ADSLstandard Gmin=0.75 and Gmax=l.33 (±2.5 dB). SNRmaxvec tables for Pe/2 of 10^{-7} and 10^{-8} with the SNRmaxvec columns scaled by 1.33 are shown in FIG. 5. For example, the SNRmaxvec value for Pe/2 of 10^{-7} and a bit allocation of 5 bits corresponds to 2.9320e + 02 divided by 1.33, equalling 2.2045e+02. As a comparison, the same bit allocation of 5 bits yields an SNRmaxvec value for Pe/2 of 10^{-8} of 2.5516e + 02.

Id. at 8:20-24.

663. Therefore, Kapoor discloses both a first and second plurality of carriers.

$(Pe/2)=10^{-7}$

BITS	SNRvec	SNRmaxvec
1	9.4580e+00	7.1113e+00
2	2.8374e+01	2.1334e+01
3	6.6206e+01	4.9779e+01
4	1.4187e+02	1.0667e+02
5	2.9320e+02	2.2045e+02
6	5.9585e+02	4.4801e+02
7	1.2012e+03	9.0313e+02
8	2.4118e+03	1.8134e+03
9	4.8330e+03	3.6339e+03
10	9.6755e+03	7.2748e+03
11	1.9361e+04	1.4557e+04
12	3.8730e+04	2.9121e+04
13	7.7470e+04	5.8248e+04
14	1.5495e+05	1.1650e+05
15	3.0991e+05	2.3302e+05

$(Pe/2)=10^{-8}$

BITS	SNRvec	SNRmaxvec
1	1.0947e+01	8.2309e+00
2	3.2841e+01	2.4693e+01
3	7.6630e+01	5.7616e+01
4	1.6421e+02	1.2346e+02
5	3.3936e+02	2.5516e+02
6	6.8967e+02	5.1855e+02
7	1.3903e+03	1.0453e+03
8	2.7915e+03	2.0989e+03
9	5.5940e+03	4.2060e+03
10	1.1199e+04	8.4204e+03
11	2.2409e+04	1.6849e+04
12	4.4828e+04	3.3705e+04
13	8.9668e+04	6.7419e+04
14	1.7935e+05	1.3485e+05
15	3.5870e+05	2.6970e+05

Fig. 5

Id. at Fig. 5 (annotated).

664. One of ordinary skill in the art would have been motivated to combine Peeters with Kapoor because both references are in regard to setting a SNR margin on the channels of a DMT system and Peeters discloses a method for communicating different types of data with different SNR margins so if a person of ordinary skill wanted to understand how to communicate three

different types of data over a DMT system, Peeters subsets would be one feasible method to do so.

665. Thus, Kapoor in view of Peeters discloses 16.e.

i. Claim 16.f "using a third SNR margin"

666. Kapoor in view of Peeters renders obvious 16.f that the transceiver is operable to demodulate for reception the third plurality of bits from the first carrier "using a third SNR margin."

667. I explained above (*see supra*, §XII.B.1.i) that Peeters also discloses the preamble of claim 16, to the extent it is limiting. I incorporate that explanation by reference here.

668. As also discussed above for at least Peeters element 16.e, the subset 1 and subset 3 carriers comprise the required "first carrier" and subset 2 carriers comprise the second carrier.

669. As also discussed above for at least Kapoor element 16.e., Kapoor describes a 5-bit allocation that requires different SNR Margins. Kapoor at 8:20-24.

670. One of ordinary skill in the art would have been motivated to combine Peeters with Kapoor because both references are in regard to setting a SNR margin on the channels of a DMT system and Peeters discloses a method for communicating different types of data with different SNR margins so if a person of ordinary skill wanted to understand how to communicate three different types of data over a DMT system, Peeters subsets would be one feasible method to do so.

671. Thus, Kapoor in view of Peeters discloses 16.f.

j. Claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,"

672. Kapoor in view of Peeters renders obvious 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier."

673. For the SNR required to maintain a specified BER, Kapoor discloses: "the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER)." *Id.* at 3:59-61. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51. A person of ordinary skill in the art would therefore understand that the SNR gap provides "an allowable increase without an increase in the bit error rate" associated with the respective carrier. *See* Kapoor at 8:34-42 (describing that different subchannels have bit allocation values calculated on different margins and different $P_e/2$ error rates).

674. I explained above (*see supra*, § XII.B.1.j) that Peeters also discloses this limitation. I incorporate that explanation by reference here.

675. Thus, Kapoor in view of Peeters discloses this 16.g.

k. Claim 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier,"

676. Kapoor in view of Peeters renders obvious 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier."

677. I incorporate by reference by analysis for claim element 16.g.

678. I explained above (*see supra*, § XII.B.1.k) that Peeters also discloses this limitation. I incorporate that explanation by reference here.

679. Thus, Kapoor in view of Peeters discloses this 16.h.

l. Claim 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,"

680. Kapoor in view of Peeters renders obvious 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier."

681. I incorporate by reference by analysis for claim element 16.g.

682. I explained above (*see supra*, § XII.B.1.l) that Peeters also discloses this limitation. I incorporate that explanation by reference here.

683. Thus, Kapoor in view of Peeters discloses this 16.i.

m. Claim 16.j "wherein the first SNR margin is different than the second SNR margin,"

684. Kapoor in view of Peeters renders obvious 16.j "wherein the first SNR margin is different than the second SNR margin."

685. I incorporate by reference by analysis for claim element 16.d.

686. "Within this inventive system and method, a framework is provided which also supports the use of different $P_e/2$ rates and SNR margins for different subchannels in a communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55. As stated in Kapoor, different SNR margins can be used for different subchannels.

687. I explained above (*see supra*, § XII.B.1.m) that Peeters also discloses this limitation. I incorporate that explanation by reference here.

688. Thus, Kapoor in view of Peeters discloses this 16.j.

n. Claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"

689. Kapoor in view of Peeters renders obvious 16.k "wherein the first SNR margin is different than the third SNR margin, and."

690. I incorporate by reference by analysis for claim element 16.d and 16.f.

691. "Within this inventive system and method, a framework is provided which also supports the use of different $P_e/2$ rates and SNR margins for different subchannels in a communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55. As stated in Kapoor, different SNR margins can be used for different subchannels.

692. I explained above (*see supra*, § XII.B.1.n) that Peeters also discloses this limitation. I incorporate that explanation by reference here.

693. Thus, Kapoor in view of Peeters discloses 16.k.

o. Claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

694. Kapoor in view of Peeters renders obvious 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

695. Kapoor discloses that a subset of channels differs from a different subset of channels such that it constitutes different carriers. Although the above description is directed to a bit allocation process in which all subchannels are analyzed and bits allocated, an alternative embodiment exists in which the bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. For example, when the communication device has completed its training sequence and is operating in 'showtime', line

degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels. "[T]he bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. . . . line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels." *Id.* at 11:35-42. Here, where the process is completed for a set of subchannels and not for the other set of subchannels, it then follows that there is a difference in the first plurality of carriers versus the second plurality of carriers.

696. Thus, Kapoor discloses 16.l.

697. I explained above (*see supra*, § XII.B.1.o) that Peeters also discloses this limitation. I incorporate that explanation by reference here.

698. Thus, Kapoor in view of Peeters discloses 16.l.

4. <u>Peter Sienpin Chow, *Bandwidth optimized digital transmission techniques for spectrally shaped channels with impulse noise*, STANFORD UNIVERSITY (May 1993) ("Chow")</u>

699. Chow discloses each element of claim 16 of the '988 Patent. I provided a brief description of Chow above (*see supra* §XII.A.4.a). I incorporate that discussion by reference here.

a. <u>Claim 16</u>

700. Claim 16 of the '988 Patent is anticipated and/or rendered obvious by Chow.

b. Claim 16.pre "An apparatus comprising: a multicarrier communications transceiver"

701. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Chow discloses claim 16.pre "An apparatus comprising: a multicarrier communications transceiver."

702. Chow applies "a **Discrete Multitone transceiver**, with optimized transmission bandwidth, to these three potential DSL applications." Chow at 78 (emphasis added). Chow also discloses "[a] detailed description of the ADSL transmission environment is presented, and results of computer simulation on the performance of a DMT transceiver for ADSL are given." *Id.* at 79. Chow also presents "result of computer simulation on the performance of a DMT transceiver for ADSL." *Id.* at 79.

703. Figure 3.1 of Chow, copied below, is a block diagram of a DMT transmitter, and Figure 3.2, also copied below, is a block diagram of a DMT receiver. Thus, Chow discloses a multicarrier communications transceiver that includes both a transmitter and a receiver.

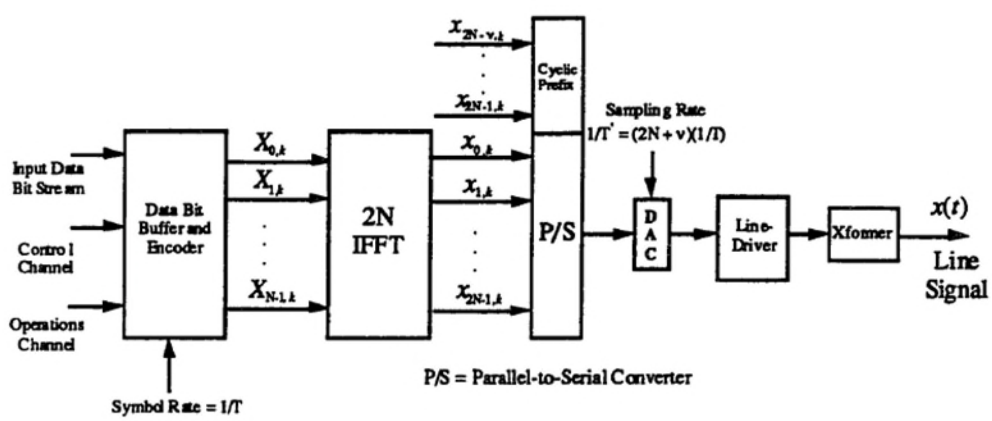


Figure 3.1: The DMT Transmitter

Id. at 3.1.

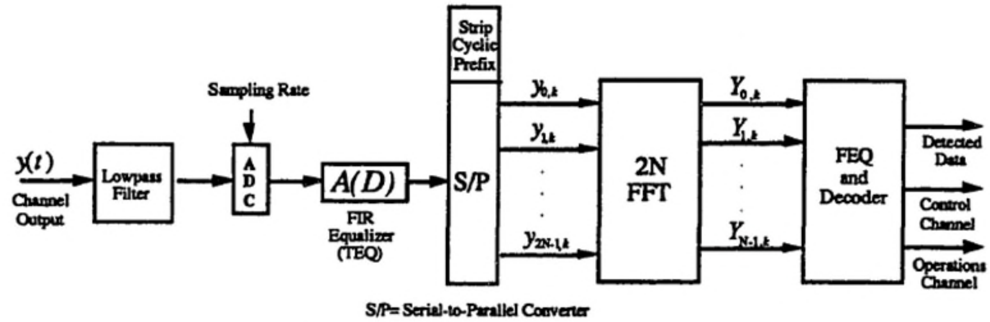


Figure 3.2: The DMT Receiver

*Id.*at 3.2.

704. Chow also discloses studying a DMT transceiver: "We studied the effect of increasing the transmit power of the DMT transceiver, holding constant the system blocklength at 512 and VHDSL crosstalk coupling at KNEXT = 2 x 10^{-15} and KFEXT x d = 2.4 x 10^{-19}. Figure 5.18 shows the achievable throughputs as a function of transmit power for various signaling rates." *Id.* at 107. "Assuming that the crosstalker uses the same signaling strategy and power level as the DMT transceiver, as the transmit power increases the crosstalk noise level increases by the same proportion, and the overall SNR remains constant." *Id.* at 107-08.

705. Chow contains further references use of a DMT system, including an "emphasis . . . on impulse noise mitigation strategies designed specifically for a multicarrier modulation system (in particular, a DMT transceiver for ADSL), we will first briefly review some of the single-carrier, impulse noise mitigation methods that have been proposed in the literature for the sake of completeness." *Id.* at 123-24.

706. Chow also recognizes the benefits of a multicarrier system over a single carrier system. Benefits mentioned include benefits that are specifically contemplated in the '354 Patent, including reduction of interference by distributing over multiple carriers as opposed to a single carrier:

> Fortunately for a multicarrier DMT transceiver, superior impulse noise immunity relative to a single-carrier system is inherent due to its block processing nature. For the ideal case of a true impulse noise occurrence that corrupts only one time domain sample, the total energy of the noise pulse is then spread evenly over every carrier, so in the case of a DMT system implemented with a length 512 FFT, its impulse noise threshold will be approximately 10 log10(512) = 27.1 dB higher than a corresponding single-carrier system. In reality, however, impulse noise occurrences may last for significantly longer than a single sample period at the ADSL sampling rates. As a result, additional protection is necessary to ensure satisfactory system performance. We will now turn our attention to a number of impulse noise mitigation strategies designed specifically for a DMT transceiver. To evaluate the performance of the various impulse noise mitigation strategies discussed in the remainder of this chapter, we make use of the set of canonical loops proposed in [57] for ADSL transceiver evaluation.

Id. at 126.

707. Moreover, Chow recognizes that different carriers of a DMT transceiver can use different margins. "If the DMT transceiver can adaptively learn the spectral shape of the impulse noise and there is sufficient extra margin available, then the extra margin can be placed intelligently on those tones most susceptible to errors due to impulse noise." *Id.* at 151.

708. Chow contemplates the same benefits as disclosed in the '354 Patent, namely the presence of a multicarrier transceiver and how the multicarrier system has increased benefits over a single carrier system:

> In Chapter 6, we examined the characteristics and studied the effects of impulse noise on a DMT system operating over an ADSL transmission environment. We proposed a number of impulse noise mitigation strategies designed specifically for a DMT transceiver that exploit both time and frequency domain characteristics of impulse noise and provide side information to the decoder for erasure declarations. Furthermore, we presented a soft decision, multicarrier, error control technique that continuously adapts both the transmitter and the receiver during normal system operation and adjusts the target system performance margin on a subchannel-by-subchannel basis. Lastly, we tested our proposed impulse noise mitigation schemes through computer simulation and found them to be quite effective in reducing the damage of impulse noise.

Id. at 164-65.

709. Thus, Chow discloses and/or renders obvious the preamble of claim 16, to the extent it is limiting.

c. Claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier"

710. Chow discloses and/or renders obvious "operable to demodulate for reception a first plurality of bits from a first carrier."

711. Chow discloses a DMT system that uses 256 subchannels, each of which always carries a plurality of bits whenever it carries any bits. *See e.g.*, Chow at 68 (N=256, b_{min}=2).

712. Figure 1.1 of Chow, copied below, is a block diagram of a digital communication system that uses multicarrier modulation and includes a modulator that is operable to demodulate for reception.

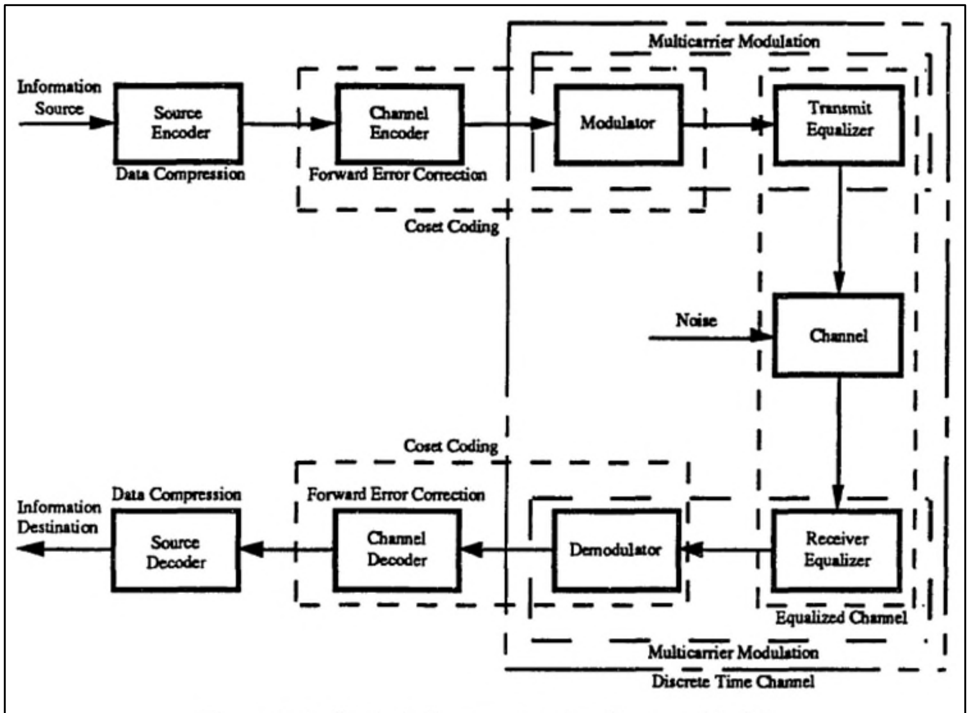


Figure 1.1: Digital Communication System Model

Id. at Fig. 1.1.

713. Figure 3.2 of Chow, copied below, is a block diagram of a DMT receiver.

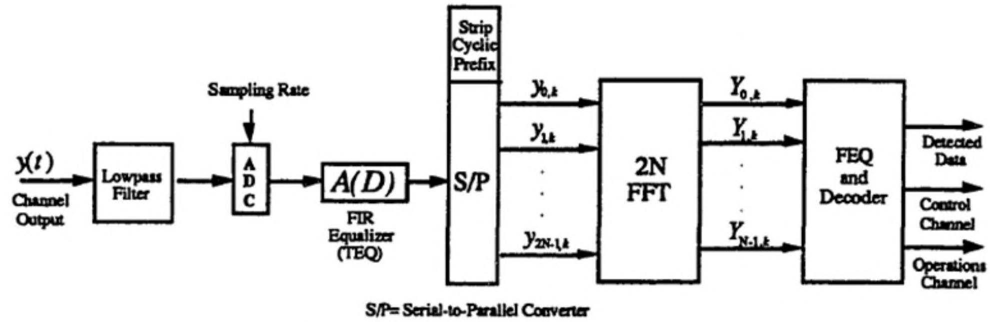


Figure 3.2: The DMT Receiver

Id. at Fig. 3.2.

714. Chow discloses that a "DMT modulator divides the data transmission channel into a fixed number of, say *N*, parallel, complex, independent subchannels in the frequency domain as shown in Figure 2.5." *Id.* at 19.

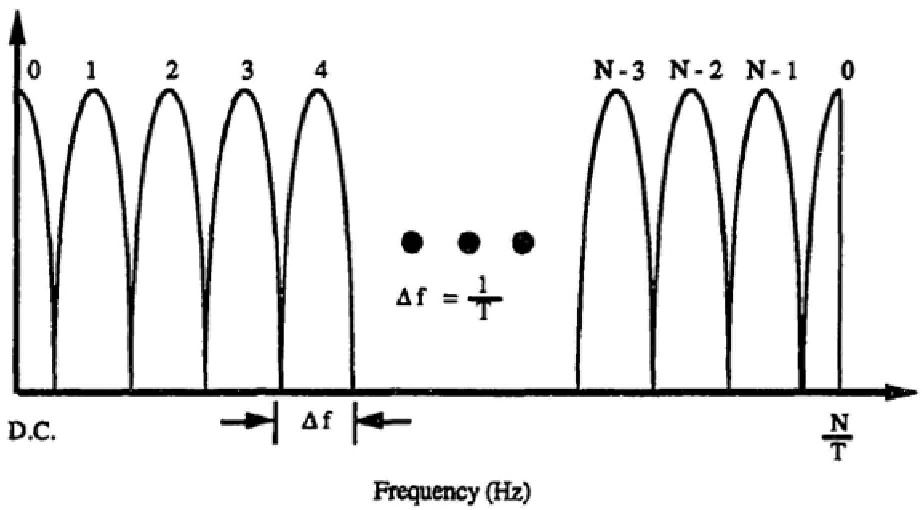


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5.

715. Chow further discloses that: "Each of the "tones", or subchannels, is $\Delta f = \frac{1}{T}$ wide in the frequency domain, where *T* is the (block) multicarrier symbol period, and if *N* is sufficiently

large, the channel power spectral density curve will be virtually flat within each of the subchannels." *Id.* at 19-20.

716. Chow also discloses that the minimum number of bits per subchannel is 2. *Id.* at 68. Therefore, every one of Chow's subchannels carries a plurality of bits. *See also id.* at Figures 6.21, 6.23, 6.25, 6.27 (illustrating that every subchannel that carries bits carries at least two bits).

717. Accordingly, Chow discloses the ability to demodulate for reception a first plurality of bits.

718. Chow also discloses that each of the subchannels in a multicarrier symbol has its own carrier: "The fundamental goal of all 'multicarrier' modulation techniques is to partition a data transmission channel with ISI into a set of orthogonal, memoryless subchannels, each with its own 'carrier.' (*See* [23] and [24]). Data is transmitted through each subchannel independently of other subchannels, and within each subchannel, the channel response is (ideally) flat, as long as the channel is partitioned sufficiently." *Id.* at 16-17.

719. Chow discloses that the multicarrier symbol comprises a first carrier because it discloses that each DMT symbol has multiple subchannels, the number of which Chow denotes as *N*. For example, Chow describes a DMT system that is used for simulation of ADSL, and that ADSL system has *N* = 256 subchannels. Chow at 86; *see also id.* at 66, 68, 106. As Chow discloses (*see, e.g.*, *id.* at 16-17), and as would have been appreciated by a person having ordinary skill in the art even absent the disclosures of Chow, each of these 256 subchannels is associated with its own carrier. Accordingly, within each DMT symbol are many pluralities of carriers, including a first carrier.

720. Thus, Chow discloses and/or renders obvious claim 16.a.

d. Claim 16.b "using a first Signal to Noise Ratio (SNR) margin"

721. Chow discloses and/or renders obvious that a transceiver is operable to demodulate for reception the first plurality of bits from the first carrier "using a first Signal to Noise Ratio (SNR) margin."

722. Chow discloses "2.2 SNR Gap and the Gap Approximation" which includes "System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement." *Id.* at 13.

723. Chow explicitly discloses that SNR margins are used to transport data. "[I]n the case of maximizing total data throughput at a fixed margin lower than the maximum achievable margin, some of the worst subchannels used may not have the necessary SNR to transport any data at the maximum achievable margin." *Id.* at 59.

724. Moreover, Chow discloses assigning pluralities of bits to carriers.

> Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution.

Id. at 69-70.

725. Chow provides many plots illustrating pluralities of bits assigned to carriers, and the use of different SNR margins on different carriers.

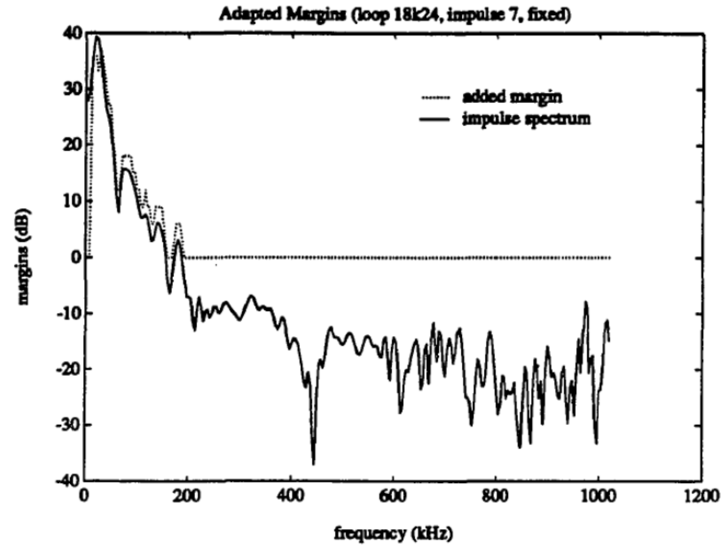


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20.

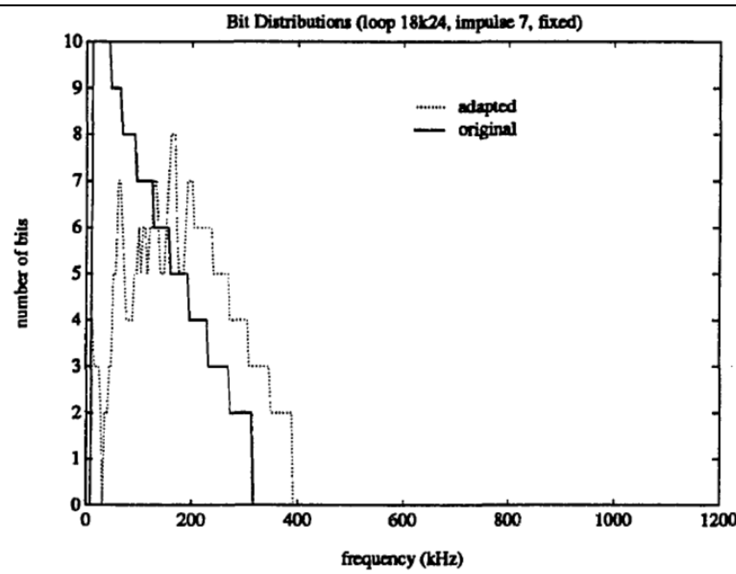


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at 6.21.

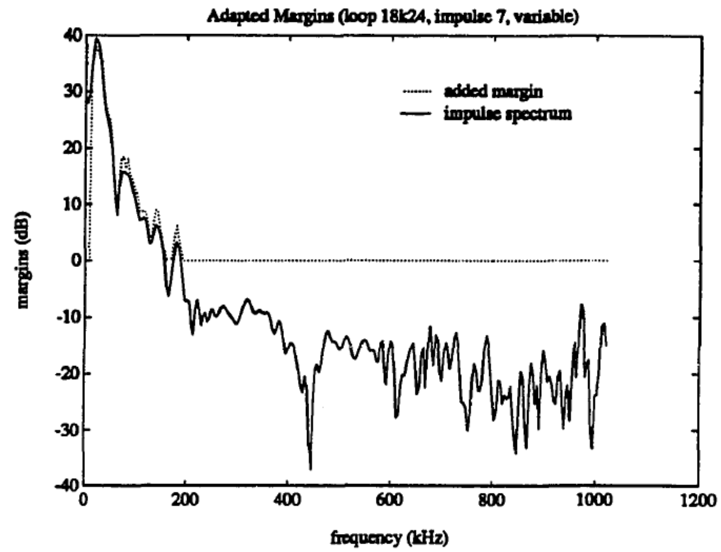


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

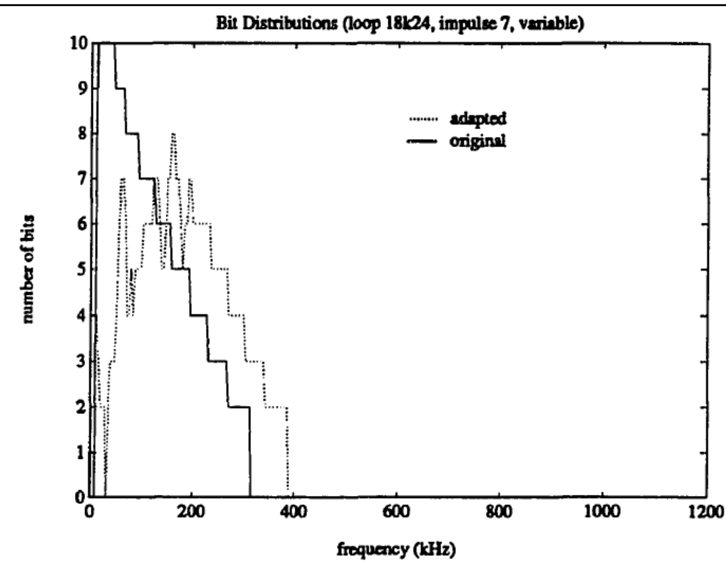


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Fig. 6.23.

726. "Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased

margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones." *Id.* at 158-60.

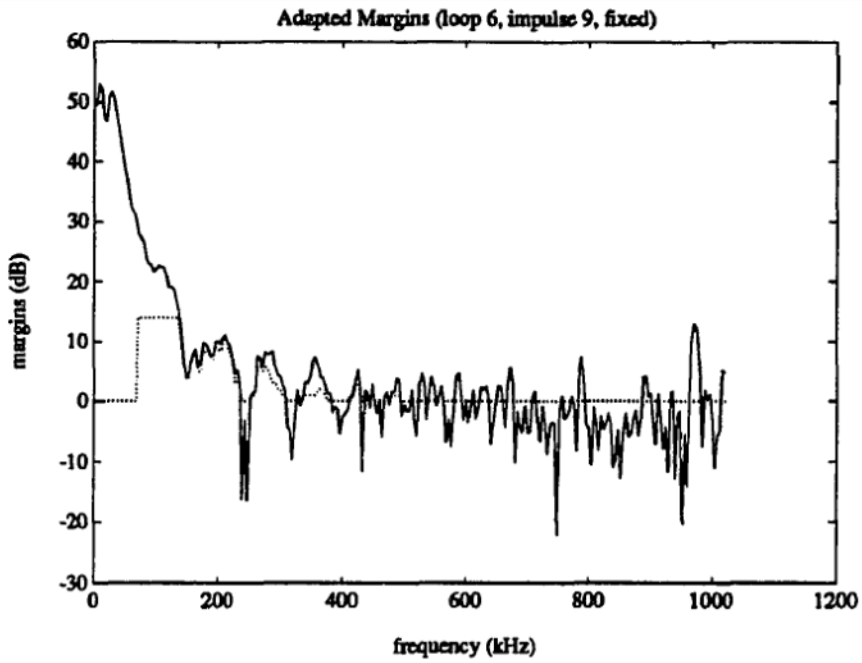


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

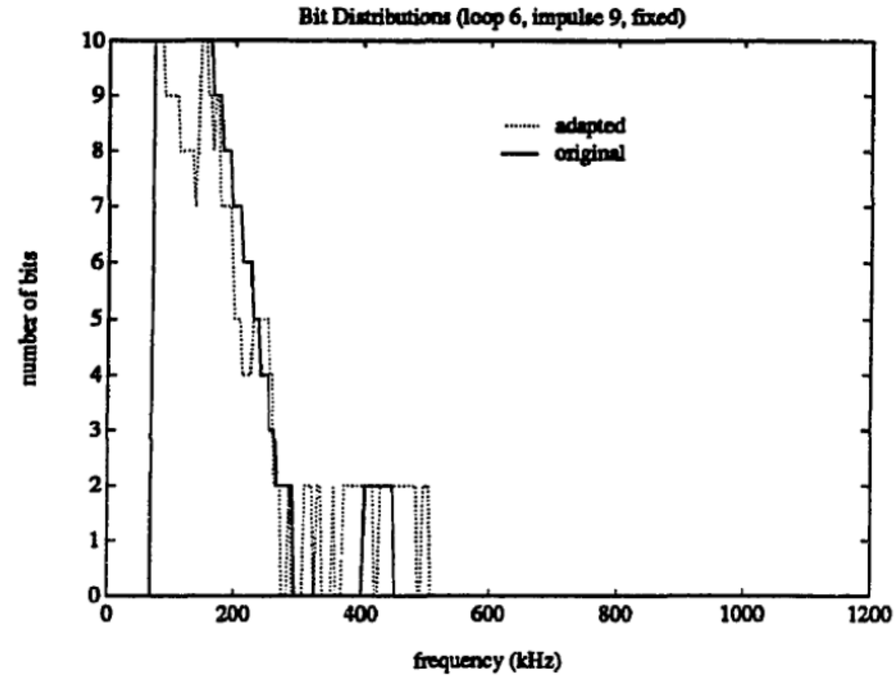


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25.

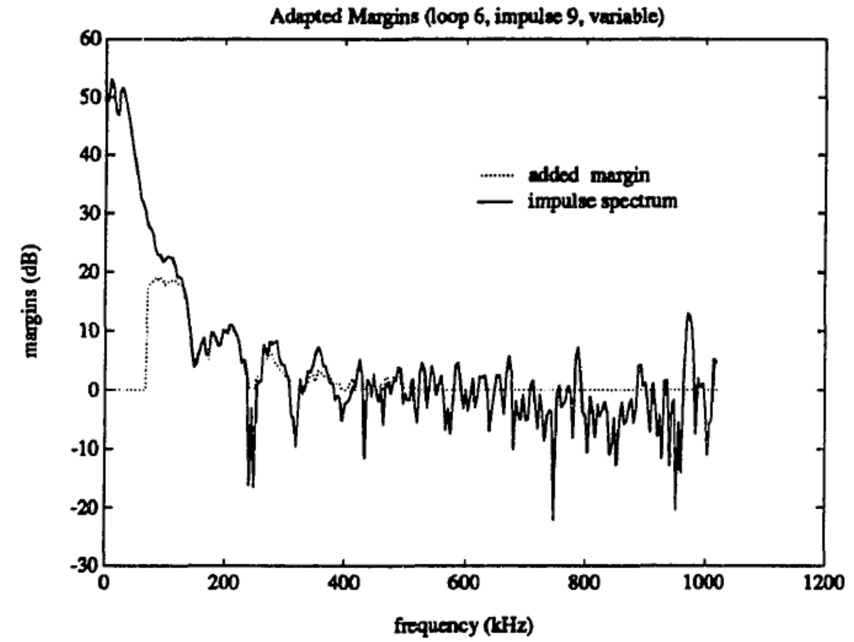


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26

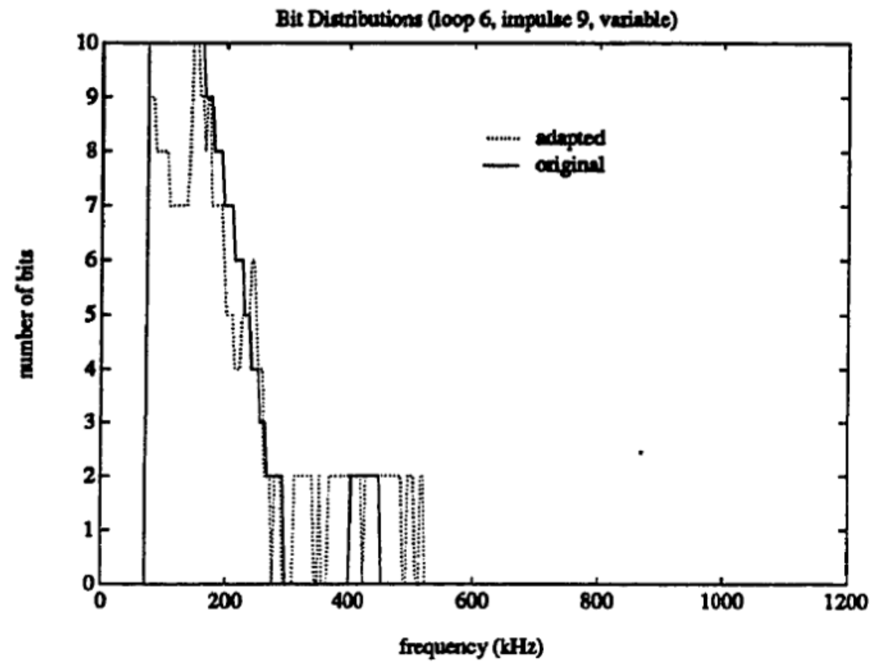


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27.

727. Thus, Chow discloses and/or renders obvious claim 16.b.

e. Claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier"

728. Chow discloses and/or renders obvious that the multicarrier communications transceiver is operable "to demodulate for reception a second plurality of bits from a second carrier."

729. Chow discloses a DMT system that uses 256 subchannels, each of which always carries a plurality of bits whenever it carries any bits. *See e.g., id.* at 68 (N=256, b_{min}=2).

730. Figure 1.1 of Chow, copied below, is a block diagram of a digital communication system that uses multicarrier modulation and includes a modulator that is operable to demodulate for reception.

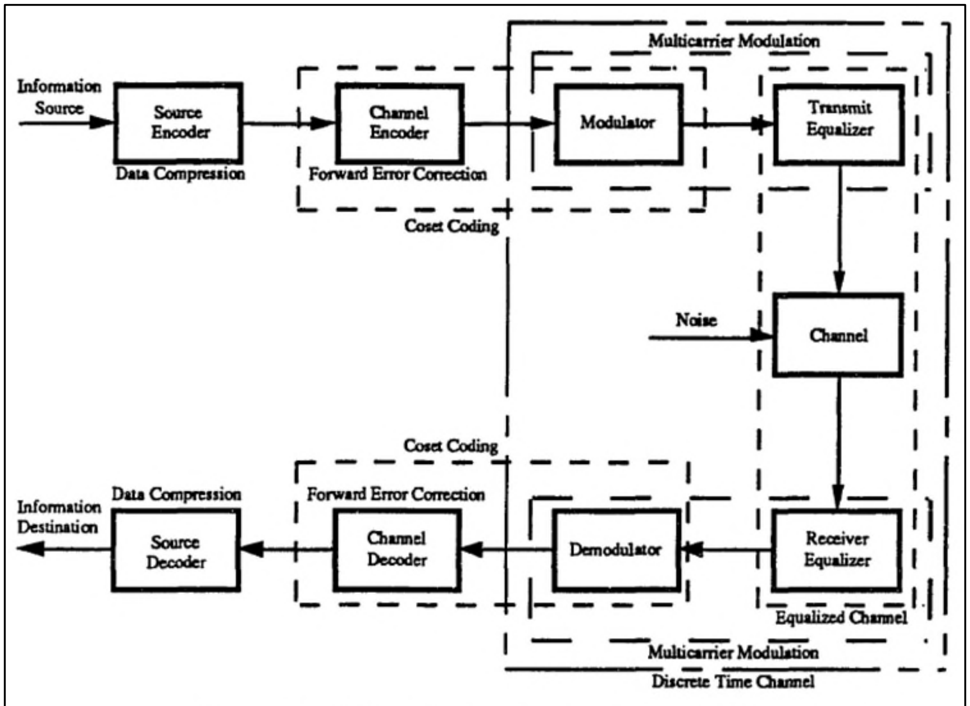


Figure 1.1: Digital Communication System Model

Id. at Fig. 1.1.

731. Figure 3.2 of Chow, copied below, is a block diagram of a DMT receiver.

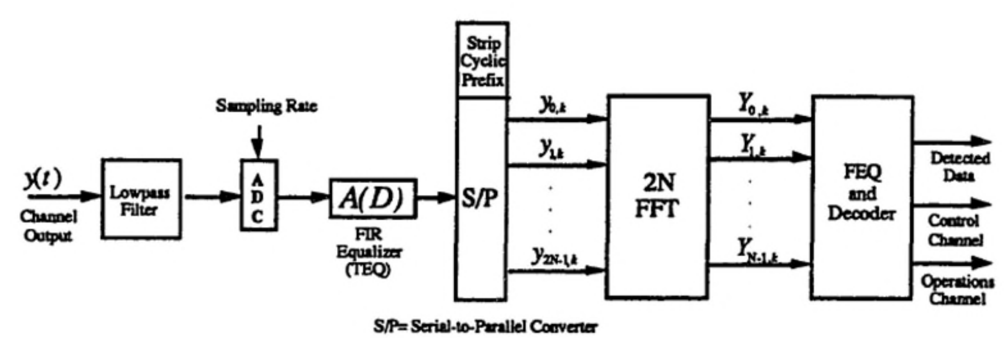


Figure 3.2: The DMT Receiver

Id. at Fig. 3.2.

732. Chow discloses that a "DMT modulator divides the data transmission channel into a fixed number of, say *N*, parallel, complex, independent subchannels in the frequency domain as shown in Figure 2.5." *Id.* at 19.

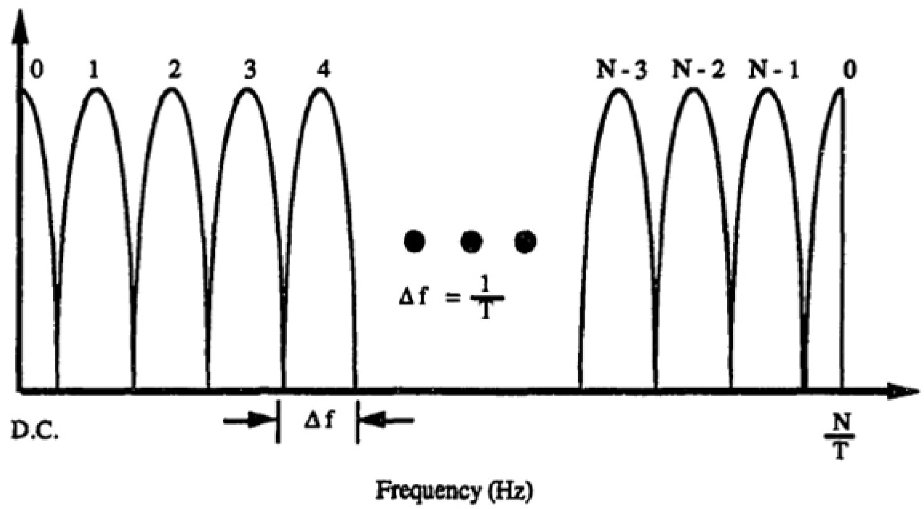


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5.

733. Chow further discloses that: "Each of the "tones", or subchannels, is $\Delta f = \frac{1}{T}$ wide in the frequency domain, where *T* is the (block) multicarrier symbol period, and if *N* is sufficiently large, the channel power spectral density curve will be virtually flat within each of the subchannels." *Id.* at 19-20.

734. Chow also discloses that the minimum number of bits per subchannel is 2. *Id.* at 68. Therefore, every one of Chow's subchannels carries a plurality of bits. *See also id.* at Figures 6.21, 6.23, 6.25, 6.27 (illustrating that every subchannel that carries bits carries at least two bits).

735. Accordingly, Chow discloses the ability to demodulate for reception a second plurality of bits.

736. Chow also discloses that each of the subchannels in a multicarrier symbol has its own carrier: "The fundamental goal of all 'multicarrier' modulation techniques is to partition a data transmission channel with ISI into a set of orthogonal, memoryless subchannels, each with its own 'carrier.' (*See* [23] and [24]). Data is transmitted through each subchannel independently

of other subchannels, and within each subchannel, the channel response is (ideally) flat, as long as the channel is partitioned sufficiently." *Id.* at 16-17.

737. Chow discloses that the multicarrier symbol comprises a second carrier, in addition to the first carrier, because it discloses that each DMT symbol has multiple subchannels, the number of which Chow denotes as *N*. For example, Chow describes a DMT system that is used for simulation of ADSL, and that ADSL system has *N* = 256 subchannels. Chow at 86; *see also id.* at 66, 68, 106. As Chow discloses (*see, e.g.*, *id.* at 16-17), and as would have been appreciated by a person having ordinary skill in the art even absent the disclosures of Chow, each of these 256 subchannels is associated with its own carrier. Accordingly, within each DMT symbol are many carriers, including a second carrier.

738. I incorporate by reference my analysis for 16.a.

739. Thus, Chow discloses and/or renders obvious claim 16.c.

f. <u>Claim 16.d "using a second SNR margin"</u>

740. Chow discloses and/or renders obvious that the multicarrier communications transceiver is operable to demodulate for reception the second plurality of bits from the second carrier "using a second SNR margin."

741. Among other things, Chow investigates techniques for improving the performance of DMT systems in the presence of impulse noise. *Id.* at 114-15. Chow notes that most practical communication systems are designed "with a built-in performance margin to take the detrimental effects of impulse noise into account." *Id.* at 114. Chow teaches that the use of different margins on different subchannels can improve robustness in the presence of impulse noise. Specifically, Chow discloses that "[i]f the DMT transceiver can adaptively learn the spectral shape of the impulse noise and there is sufficient extra margin available, then the extra margin can be placed intelligently on those tones most susceptible to errors due to impulse noise." *Id.* at 114, 151.

Thus, Chow teaches that the performance of a DMT system can be improved by detecting whether a subchannel is suffering from impulse noise and, if it is, allocating excess margin to that subchannel. As would have been recognized by a person having ordinary skill in the art, the result of this allocation would be that different subchannels would have different margins. Specifically, a first carrier would have a first SNR margin, and a second carrier would have a second SNR margin.

742. Chow teaches monitoring "the occurrence of a large number of unusually high error signals over the carriers in a DMT symbol" and using a threshold to decide whether "the error signal on a particular subchannel is 'unusually high.'" *Id.* at 151. When more than a threshold number of subchannels have been found to have unusually high error signals, Chow teaches that an impulse is likely to be present. *Id.* In response, "the estimate of the impulse spectrum is updated, using the mean squared error signals on all of the subchannels." *Id.* at 151-52. Chow defines a running sum, α_{ij}, which is the impulse spectral estimate on subchannel *i* at time *j*. *Id.* at 152. Chow also defines another threshold, *impthresh*, and teaches that after some number of suspected impulse occurrences, "additional margin will be given to those subchannels with mean squared error estimates, α_{ij}," that exceed *impthresh*. *Id.* Chow explains in detail how to determine how much additional margin to allocate to each subchannel whose mean squared error estimate, α_{ij}, exceeds *impthresh*, and Chow presents the results of multiple simulations illustrating the effect of the disclosed techniques. *See id.* at 152-61.

743. Figures 6.20 through 6.27 of Chow illustrate many possible second pluralities of bits on second pluralities of carrier using a second SNR margin. In the annotated versions below, I have indicated in blue the locations of several possible second carriers and second pluralities of

bits on the second carrier. For example, the second carrier can be within the blue area and therefor use no added margin (e.g., it can simply use whatever the base margin is).

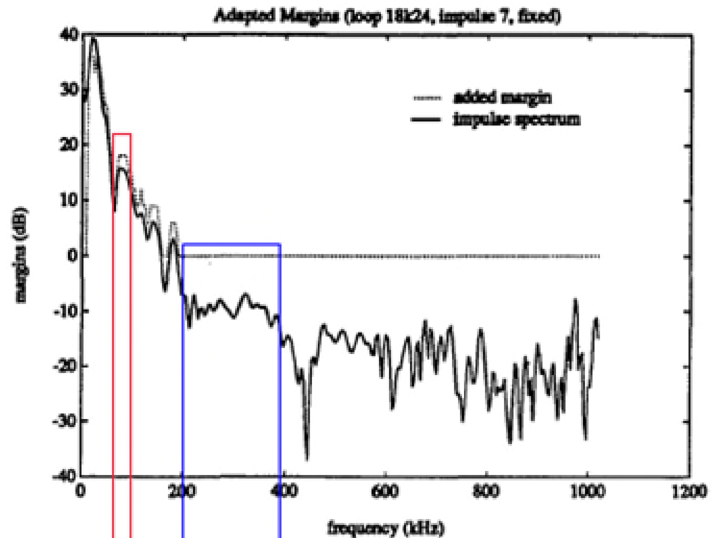


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

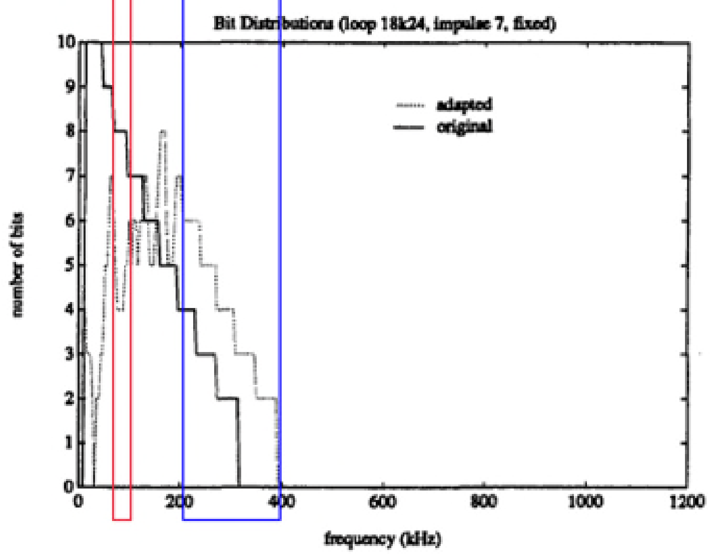


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Figs. 6.20, 6.21 (annotated).

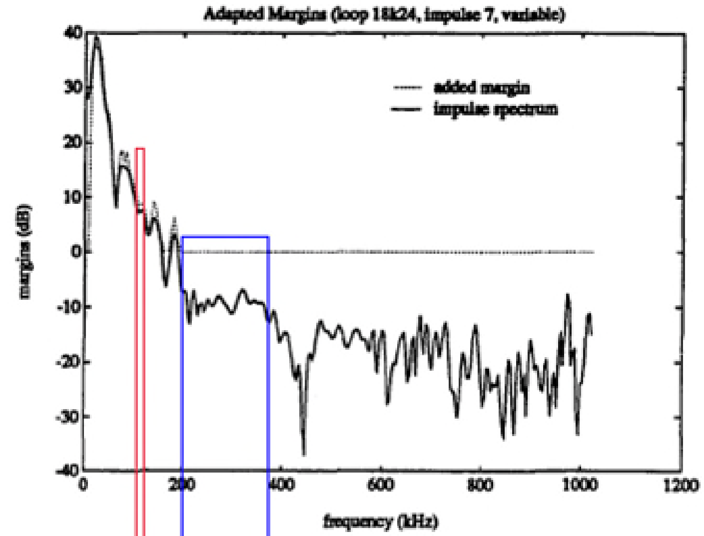


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

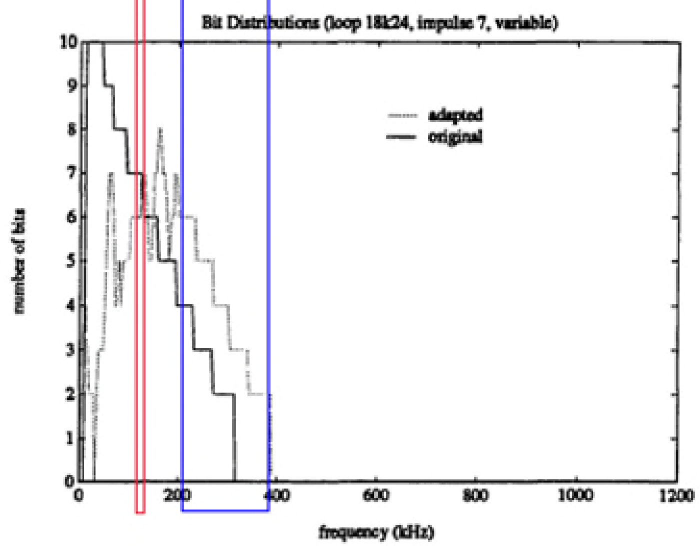


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Figs. 6.22, 6.23 (annotated).

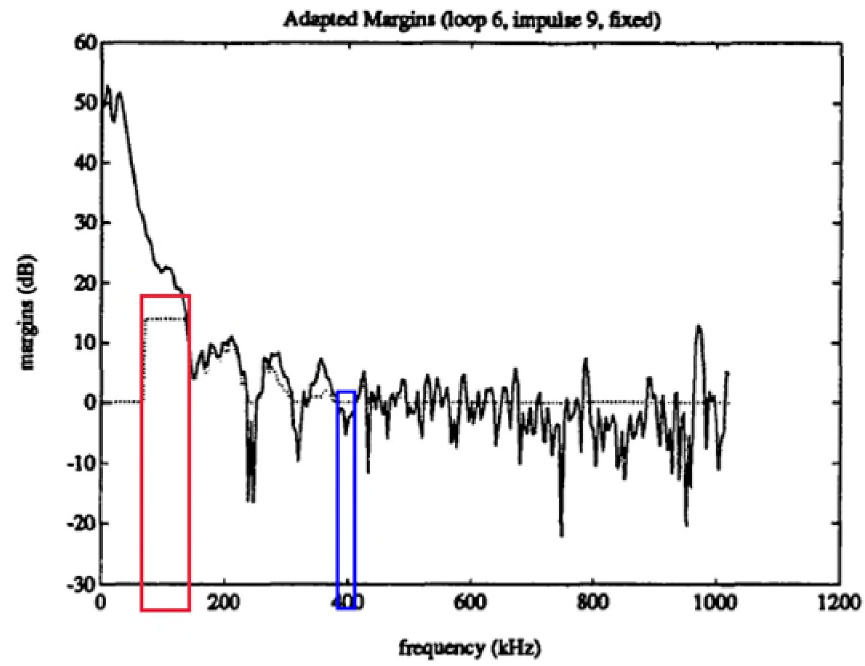


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at. Fig. 6.24 (annotated).

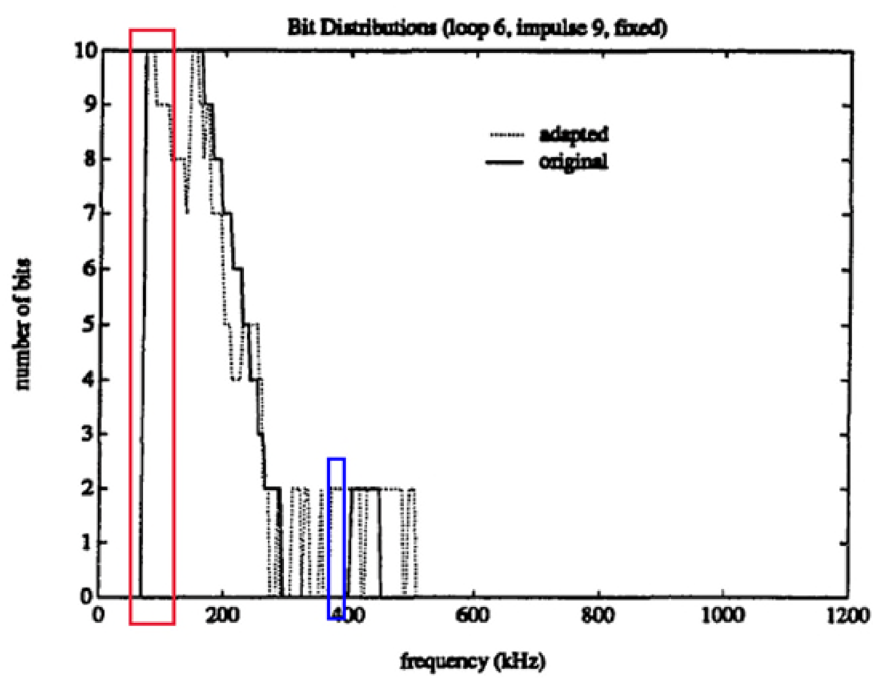


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25 (annotated).

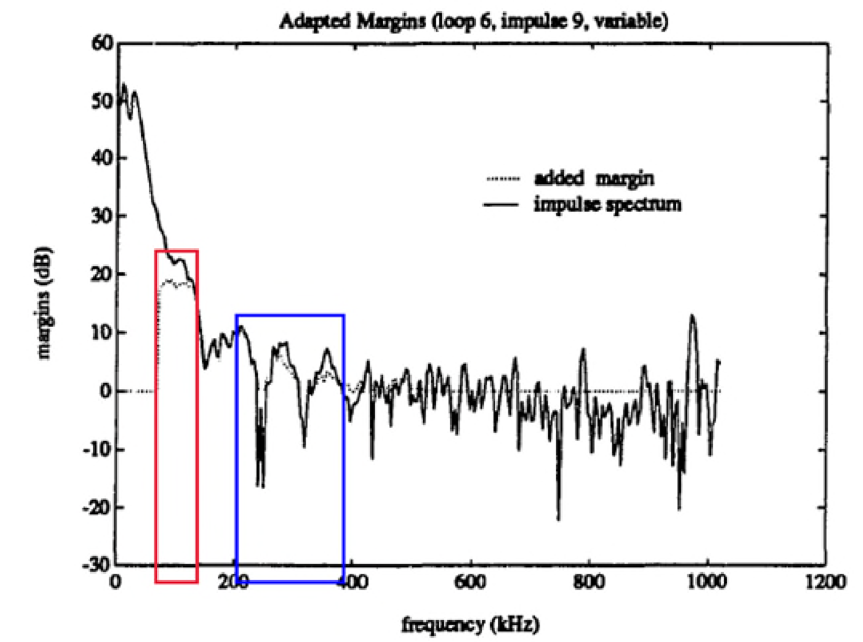


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26 (annotated).

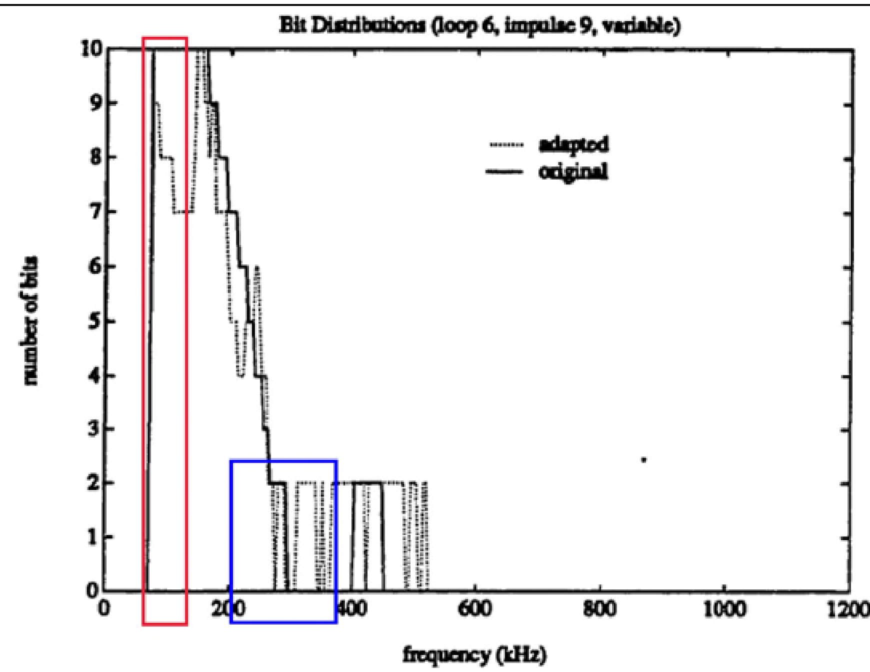


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at. Fig. 6.27 (annotated).

744. Chow details how there can be a delineation of a first carrier and a second carrier such that there can be a second plurality of bits on a second carrier using a second SNR margin. "The performance of this frequency domain clipping technique in general depends on the manner in which power is allocated among the carriers, the channel transfer function, and the actual number of carriers used." *Id.* at 143. In particular "This figure [6.21] clearly demonstrates the ability of a DMT system to move bits from the lower carriers to the higher carriers in order to avoid the large low frequency content of the injected impulse noise. In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

> Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution.

Id. at 69-70.

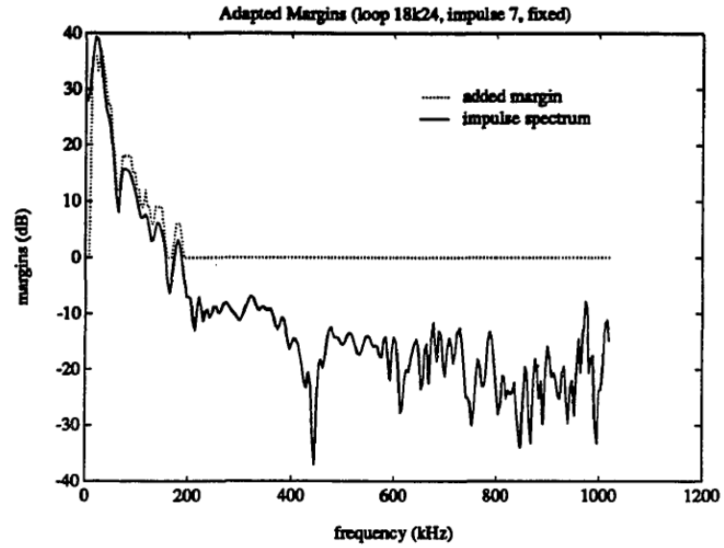


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20.

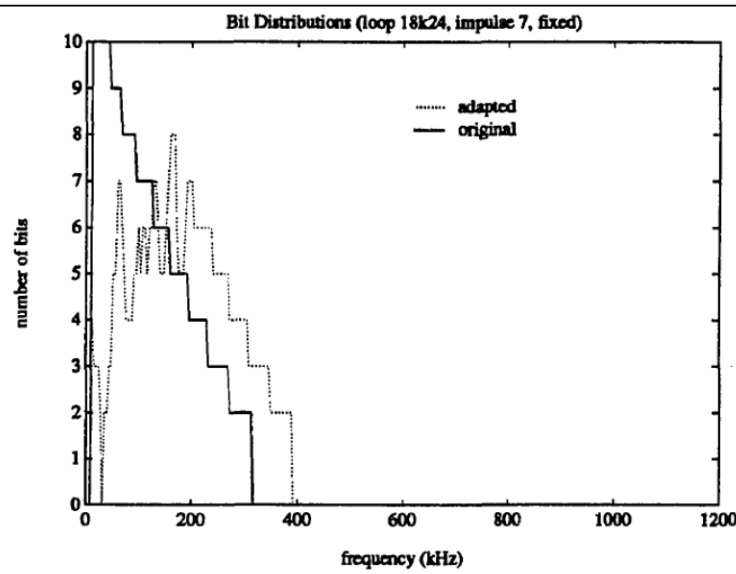


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Fig. 6.21.

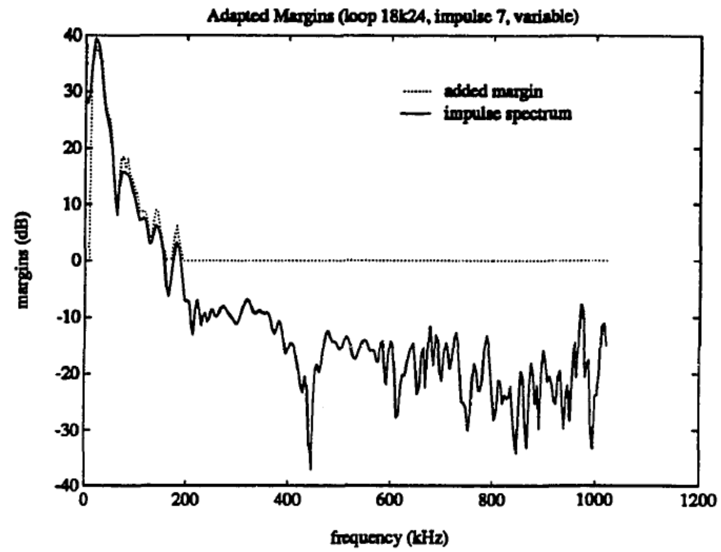


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

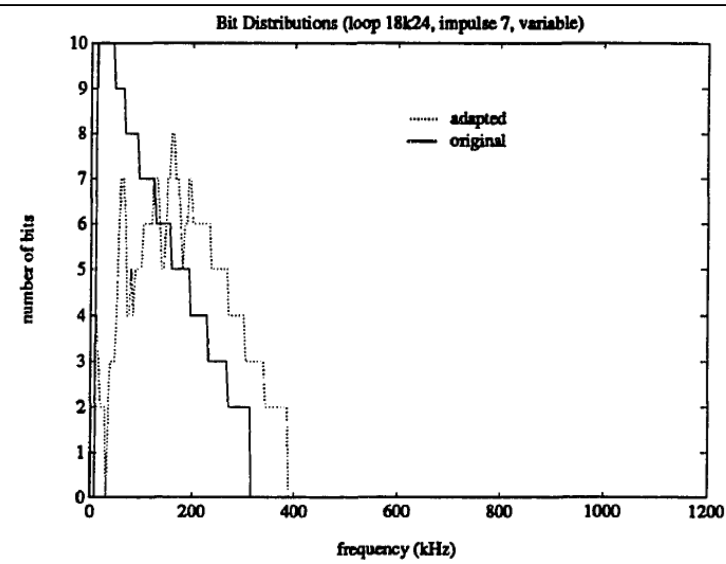


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Fig. 6.23.

745. "Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased

margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones." *Id.* at 158-60.

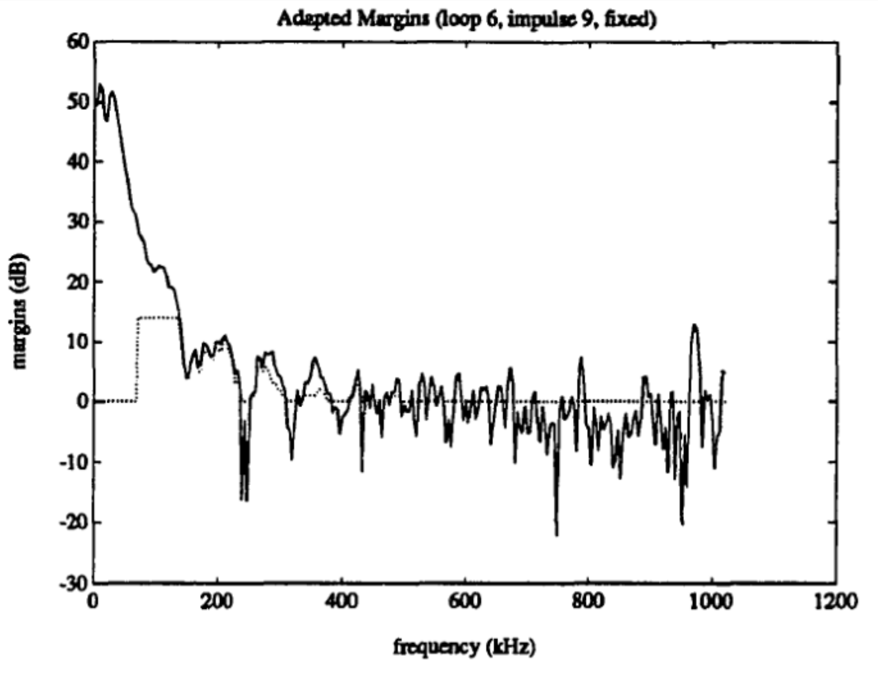


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

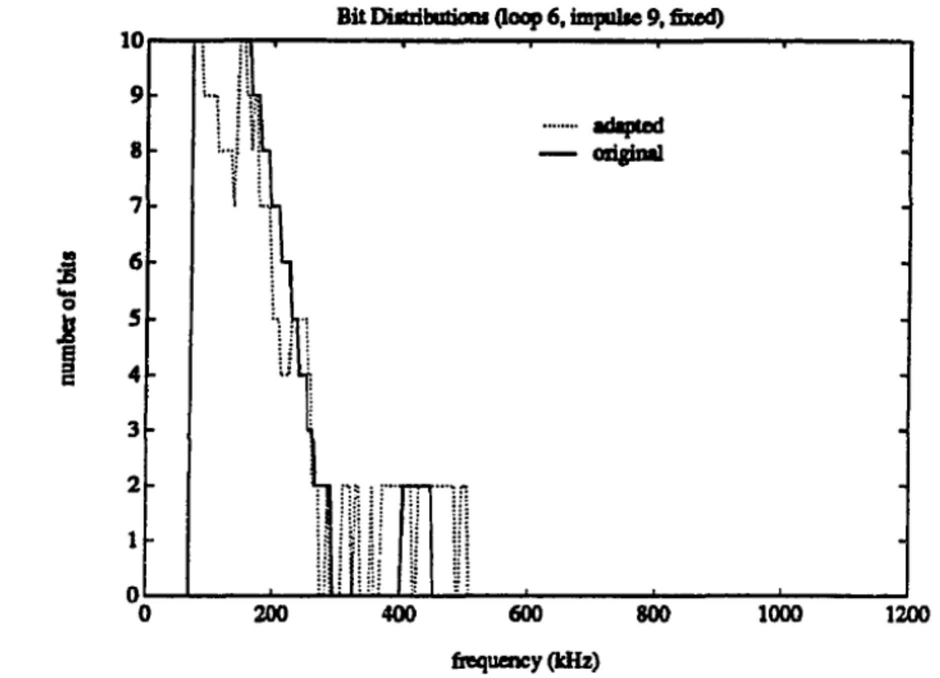


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25.

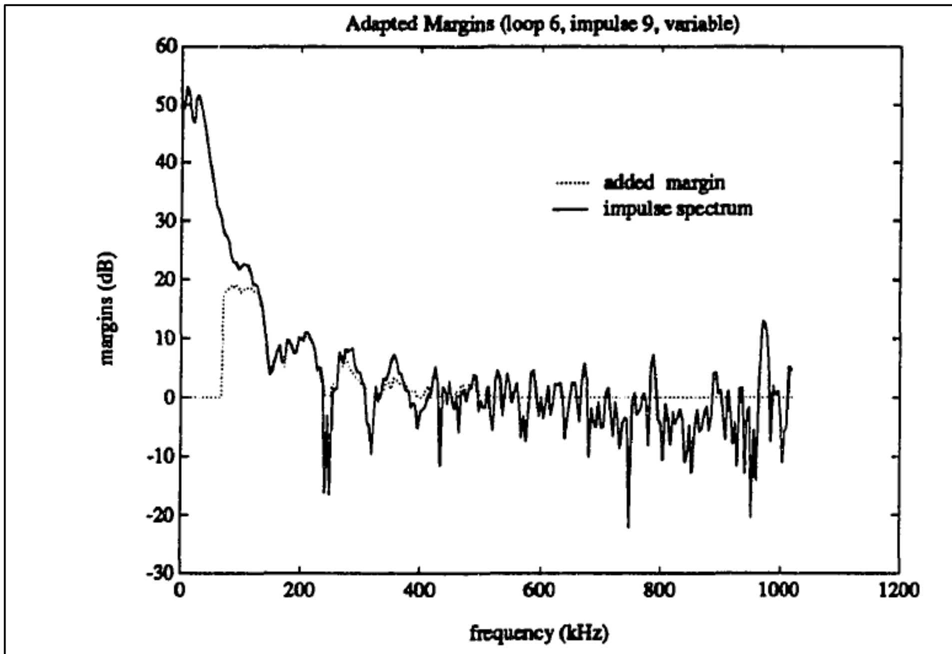


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26

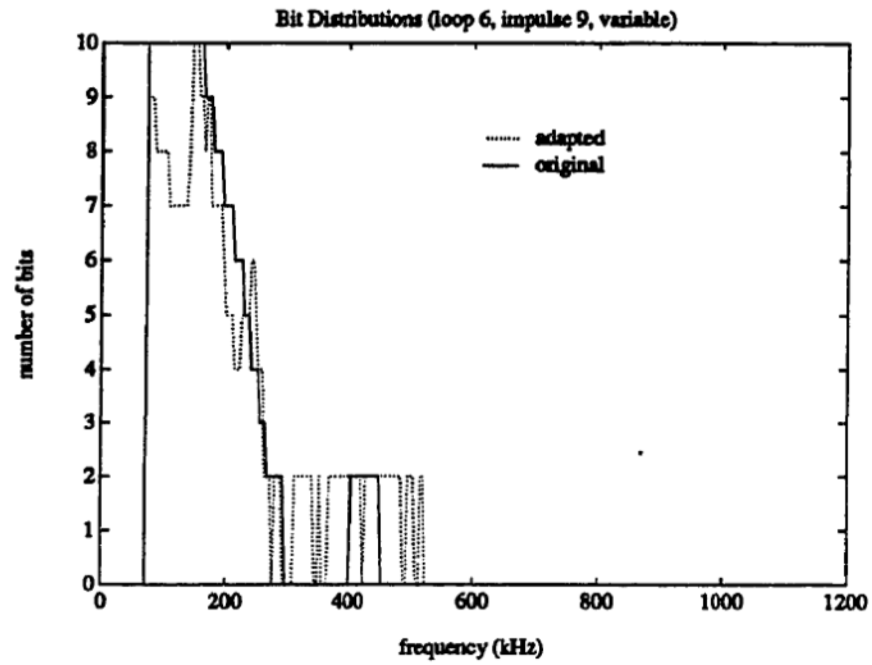


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27.

746. "The performance of this frequency domain clipping technique in general depends on the manner in which power is allocated among the carriers, the channel transfer function, and the actual number of carriers used." *Id.* at 143.

747. "This figure clearly demonstrates the ability of a DMT system to move bits from the lower carriers to the higher carriers in order to avoid the large low frequency content of the injected impulse noise. In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

748. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

749. "Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution." *Id.* at 69-70.

750. Thus, Chow discloses and/or renders obvious claim 16.d.

g. <u>Claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier"</u>

751. Chow discloses and/or renders obvious "and to demodulate for reception a third plurality of bits from the first carrier."

752. Chow discloses a DMT system that uses 256 subchannels, each of which always carries a plurality of bits whenever it carries any bits. *See e.g.*, Chow at 68 (N=256, b_{min}=2).

753. Figure 1.1 of Chow, copied below, is a block diagram of a digital communication system that uses multicarrier modulation and includes a modulator that is operable to demodulate for reception.

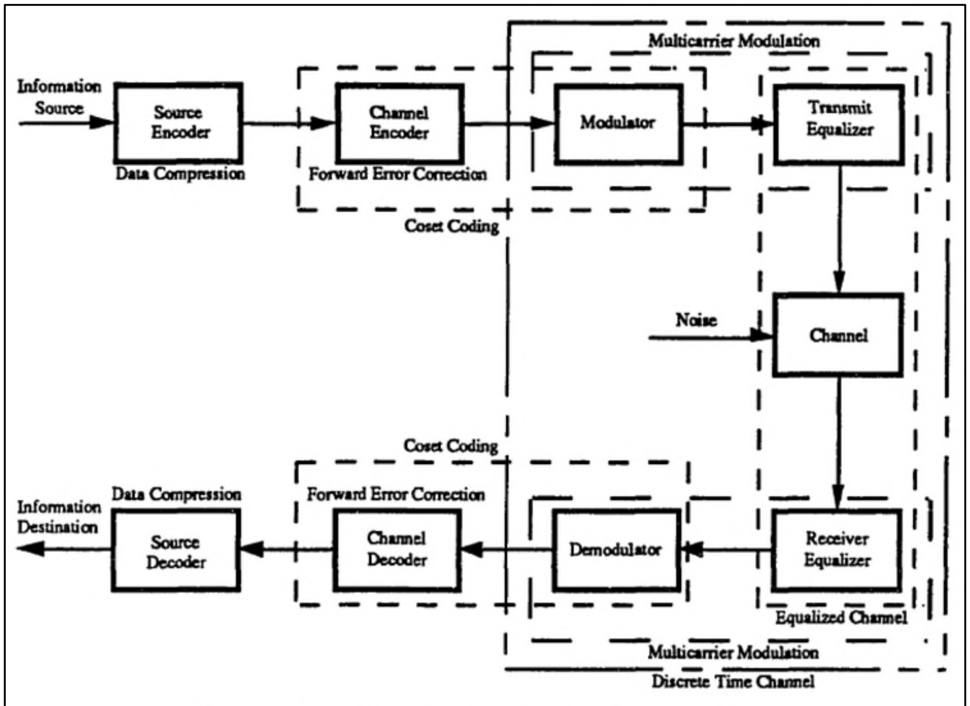


Figure 1.1: Digital Communication System Model

Id. at Fig. 1.1.

754. Figure 3.2 of Chow, copied below, is a block diagram of a DMT receiver.

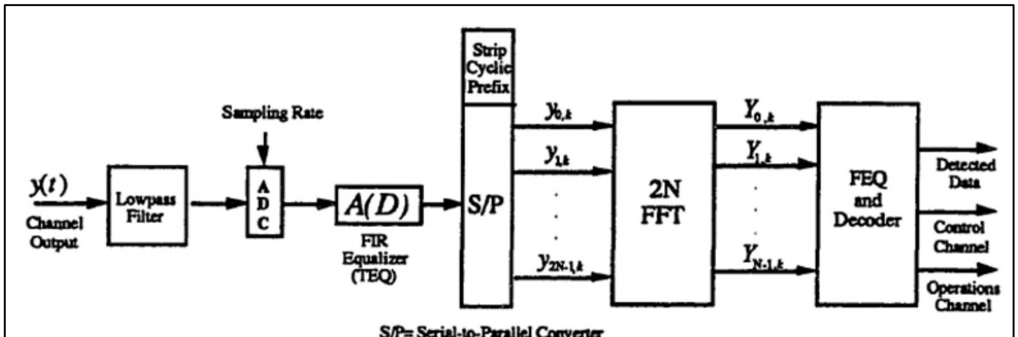


Figure 3.2: The DMT Receiver

Id. at Fig. 3.2.

755. Chow discloses that a "DMT modulator divides the data transmission channel into a fixed number of, say *N*, parallel, complex, independent subchannels in the frequency domain as shown in Figure 2.5." *Id.* at 19.

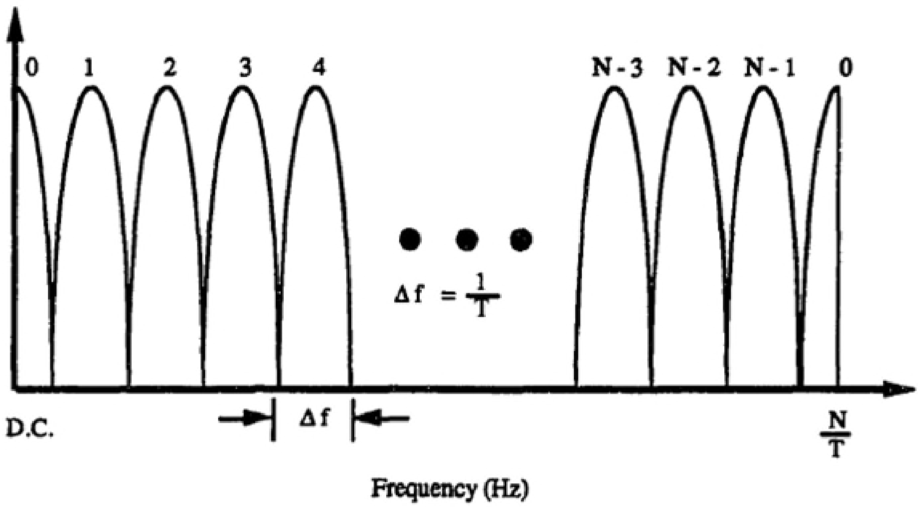


Figure 2.5: Frequency Domain Picture of DMT Modulation

Id. at Fig. 2.5.

756. Chow further discloses that: "Each of the "tones", or subchannels, is $\Delta f = \frac{1}{T}$ wide in the frequency domain, where *T* is the (block) multicarrier symbol period, and if *N* is sufficiently large, the channel power spectral density curve will be virtually flat within each of the subchannels." *Id.* at 19-20.

757. Chow also discloses that the minimum number of bits per subchannel is 2. *Id.* at 68. Therefore, every one of Chow's subchannels carries a plurality of bits. *See also id.* at Figures 6.21, 6.23, 6.25, 6.27 (illustrating that every subchannel that carries bits carries at least two bits).

758. Accordingly, Chow discloses the ability to demodulate for reception a third plurality of bits.

759. "The fundamental goal of all "multicarrier" modulation techniques is to partition a data transmission channel with ISI into a set of orthogonal, memoryless subchannels, each with its own "carrier." (*See* [23] and [24]). Data is transmitted through each subchannel independently

of other subchannels, and within each subchannel, the channel response is (ideally) flat, as long as the channel is partitioned sufficiently." *Id.* at 16-17.

760. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

761. I incorporate by reference my analysis for 16.a and 16.c.

762. Thus, Chow discloses and/or renders obvious claim 16.e.

h. <u>Claim 16.f "using a third SNR margin"</u>

763. Chow discloses and/or renders obvious that the transceiver is operable to demodulate for reception the third plurality of bits from the first carrier "using a third SNR margin."

764. Chow discloses "2.2 SNR Gap and the Gap Approximation" which includes "System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement." *Id.* at 13.

765. Chow explicitly discloses that SNR margins are used to transport data. "[I]n the case of maximizing total data throughput at a fixed margin lower than the maximum achievable margin, some of the worst subchannels used may not have the necessary SNR to transport any data at the maximum achievable margin." *Id.* at 59.

766. Moreover, Chow discloses assigning pluralities of bits to carriers.

> Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution.

Id. at 69-70.

767. Chow provides many plots illustrating pluralities of bits assigned to carriers, and the use of different SNR margins on different of those carriers.

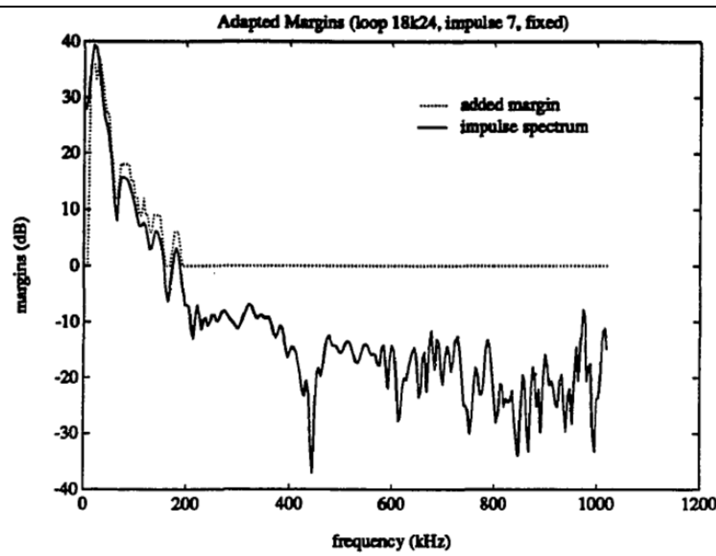


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20.

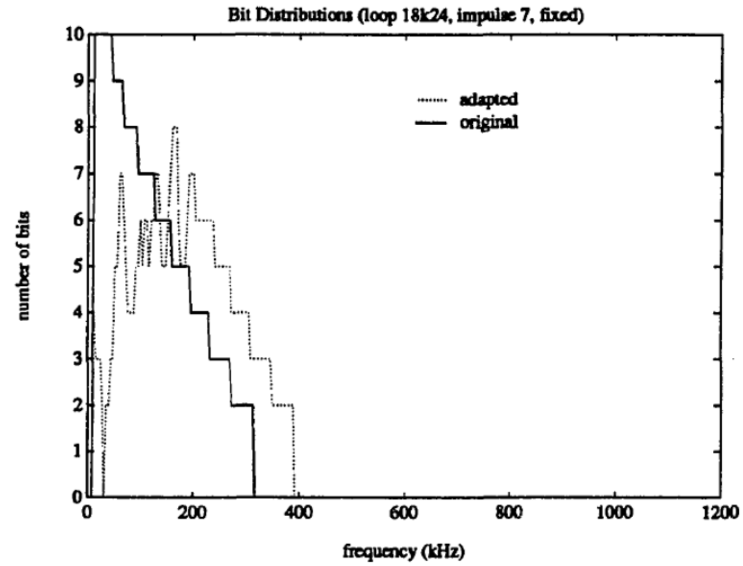


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at 6.21.

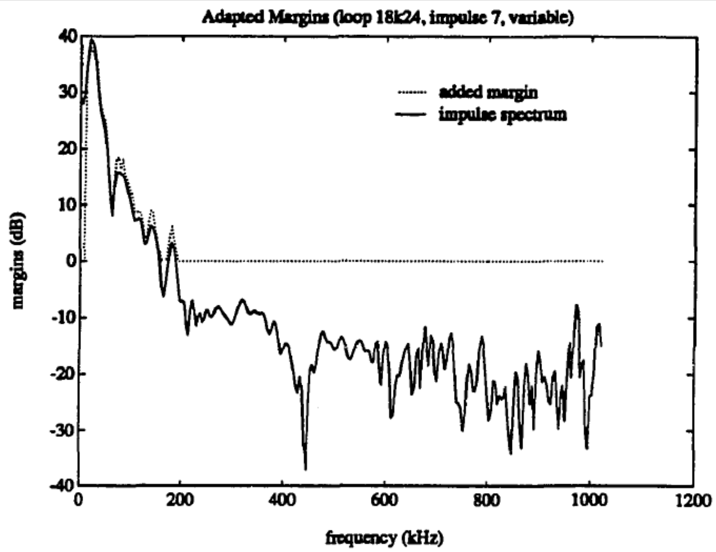


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

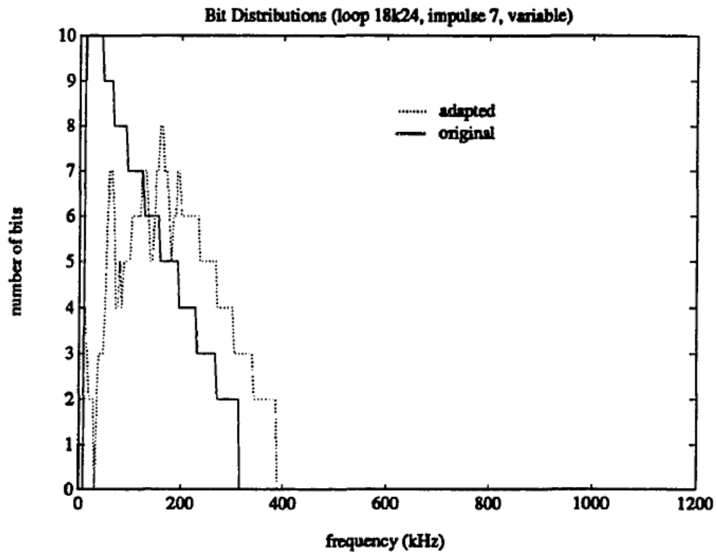


Figure 6.23: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Variable Updates

Id. at Fig. 6.23.

768. "Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones." *Id.* at 158-60.

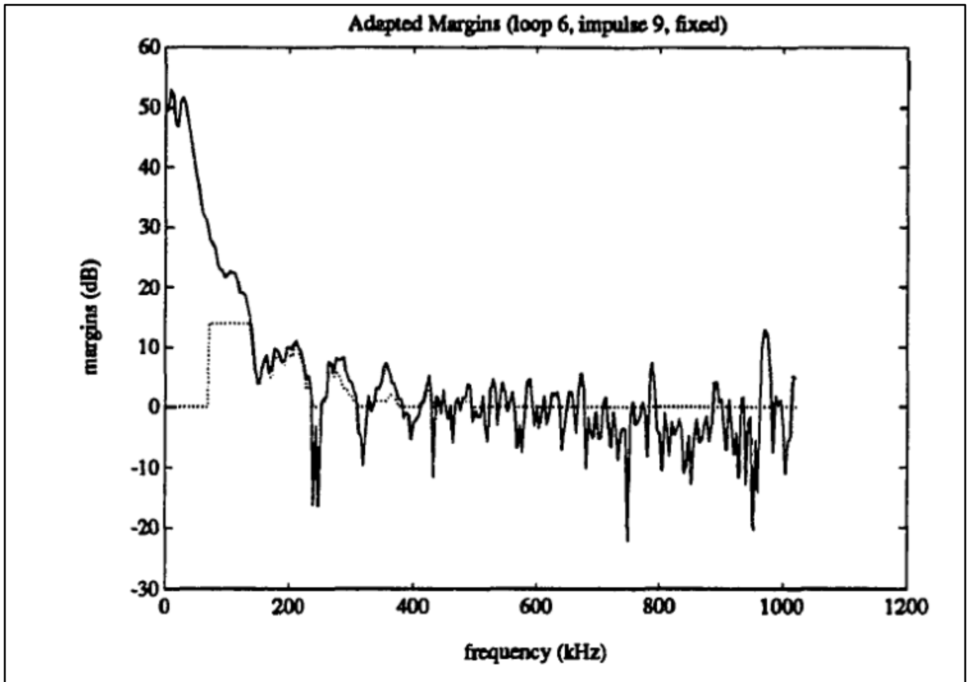


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

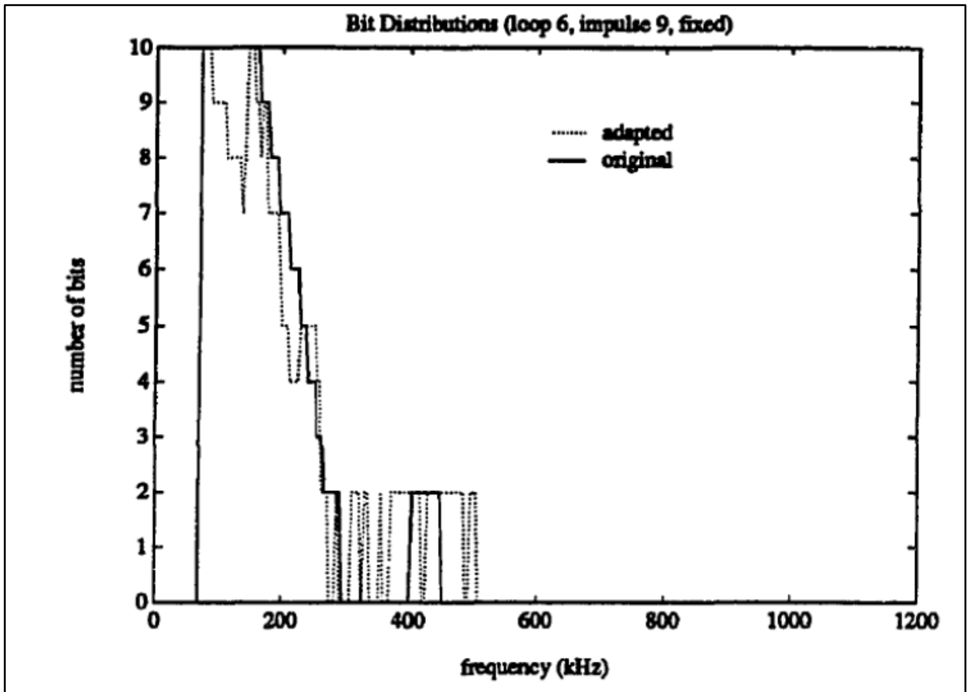


Figure 6.25: Bit Table for Loop 6, Impulse 9, and Fixed Updates

Id. at Fig. 6.25.

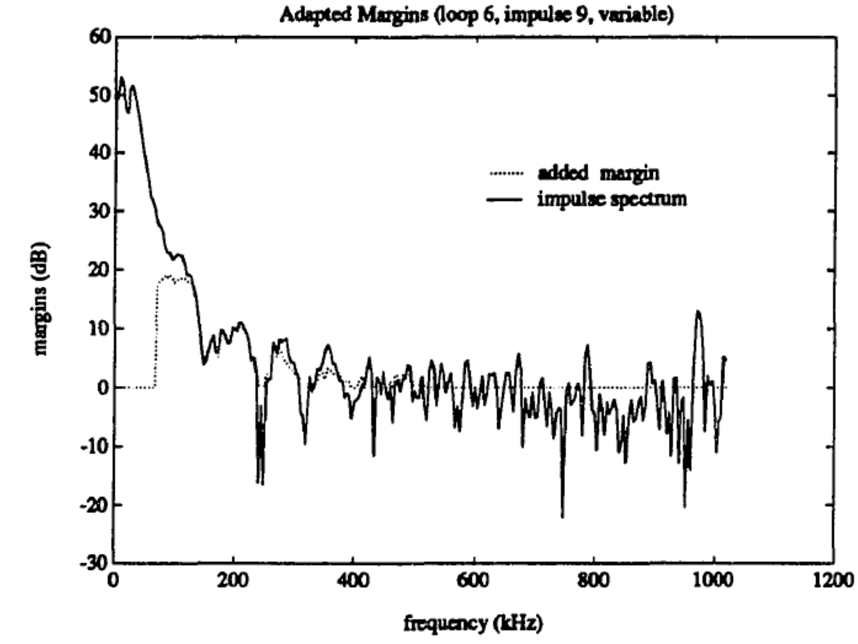


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26

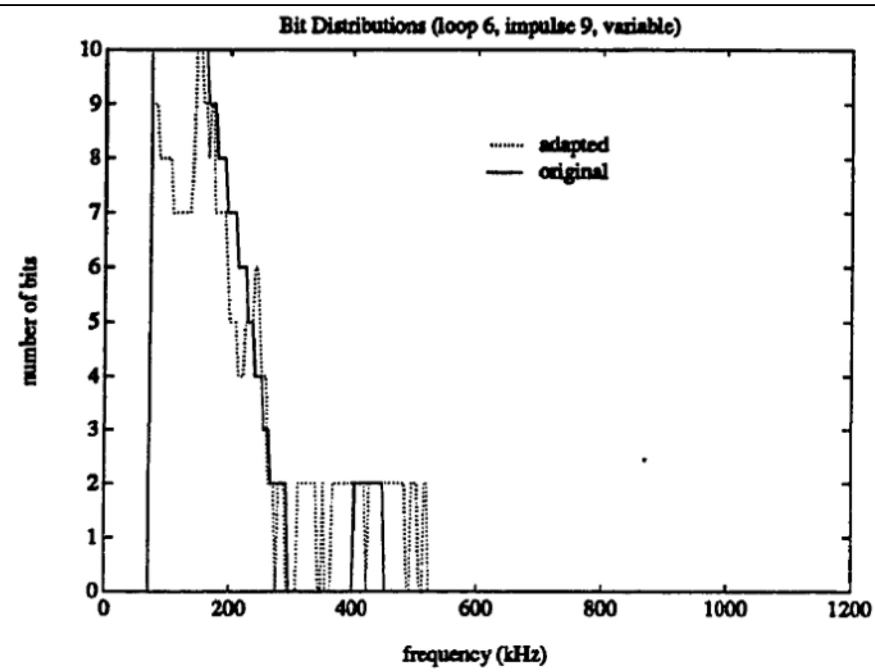


Figure 6.27: Bit Table for Loop 6, Impulse 9, and Variable Updates

Id. at Fig. 6.27.

769. Chow also describes updating the added margins as additional impulse noise is detected. Chow teaches monitoring "the occurrence of a large number of unusually high error signals over the carriers in a DMT symbol" and using a threshold to decide whether "the error signal on a particular subchannel is 'unusually high.'" Chow at 151. When more than a threshold number of subchannels have been found to have unusually high error signals, Chow teaches that an impulse is likely to be present. *Id.* In response, "the estimate of the impulse spectrum is updated, using the mean squared error signals on all of the subchannels." *Id.* at 151-52. Chow defines a running sum, α_ij, which is the impulse spectral estimate on subchannel i at time j. *Id.* at 152. Chow also defines another threshold, impthresh, and teaches that after some number of suspected impulse occurrences, "additional margin will be given to those subchannels with mean squared error estimates, α_ij," that exceed impthresh. *Id.* Chow explains in detail how to determine how much additional margin to allocate to each subchannel whose mean squared error estimate, α_ij, exceeds impthresh, and Chow presents the results of multiple simulations illustrating the effect of the disclosed techniques. *See id.* at 152-61. Chow discloses that "[t]he effect of adding margin to some of the tones is to force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible, using the adaptive bit swap algorithm presented in Section 4.3.5." *Id.* at 153.

770. Chow also discloses that the technique of allocating additional margin to subchannels affected by impulse noise "continuously adapts both the transmitter and the receiver during normal system operation and adjusts the target system performance margin on a subchannel-by-subchannel basis." *Id.* at 165. Thus, Chow discloses that the first carrier uses a first SNR margin at a first time, and then, following the adaptation, the first carrier uses a second SNR margin that is different from the first SNR margin.

771. "This figure clearly demonstrates the ability of a DMT system to move bits from the lower carriers to the higher carriers in order to avoid the large low frequency content of the injected impulse noise. In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

772. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

> Here we have also imposed a minimum of 2 bits per used carrier constraint, even though in practice, it is possible to implement 1 bit carriers. We note here that we can always combine two 1 bit carriers into one 2 bit carrier by assigning 2 bits to the original 1 bit carrier with the higher SNR and 0 bit to the original 1 bit carrier with the lower SNR. Then if we place twice the power in the carrier that is now carrying 2 bits and no power in the now 0 bit carrier, we will always do no worse than the original two 1 bit carriers with equal amount of energy in each carrier. The saw-tooth shaped input power distribution is resulting from the fact that the variation in SNR is relatively small between adjacent subchannels (a necessary condition for multicarrier to work well) and that the final power distribution will vary inversely to compensate for the SNR variation in order to maintain a constant bit error rate among all used subchannels. When the input power to a particular subchannel has increased (or decreased) to the level where it is no longer effective to transmit that particular number of bits, the number of bits is decreased (or increased) by one and the amount of input power will be abruptly decreased (or increased) by approximately 3 dB, resulting in a saw-tooth shaped final input power distribution."

Id. at 69-70.

773. I incorporate by reference my analysis for 16.b and 16.d.

774. Thus, Chow discloses and/or renders obvious claim 16.f.

i. Claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,"

775. Chow discloses and/or renders obvious "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier."

776. Chow describes the use of an SNR margin as recited in this element: "System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement." *Id.* at 13 n.1.

777. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

778. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

779. I incorporate by reference my analysis for claim limitations 16.pre through 16.f.

780. To the extent it is determined that Chow does not sufficiently disclose "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier," this element would have been obvious to a person having ordinary skill in the art because it is simply a restatement of the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as

of the ’988 patent’s priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 (“Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design.”); G.992.1, § 9.5.1 (“Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.”).

781. Thus, Chow discloses and/or renders obvious claim 16.g.

j. **Claim 16.h “wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier,”**

782. Chow discloses and/or renders obvious “wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier.”

783. “System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement.” *Id.* at 13 n.1.

784. “Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR’s and less data can be transmitted over those subchannels with smaller SNR’s. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner,

either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

785. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

786. I incorporate by reference my analysis for claim elements 16.pre through 16.g.

787. To the extent it is determined that Chow does not sufficiently disclose "wherein the second SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier," this element would have been obvious to a person having ordinary skill in the art because it is simply a restatement of the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as of the '988 patent's priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

788. Thus, Chow discloses and/or renders obvious claim 16.h.

k. Claim 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,"

789. Chow discloses and/or renders obvious "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier."

790. "System performance, or noise, margin is defined as the additional amount of noise (in dB) that the system can tolerate while still operating under the desired BER requirement." *Id.* at 13 n.1.

791. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

792. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

793. I incorporate by reference my analysis for claim elements 16.pre through 16.h.

794. To the extent it is determined that Chow does not sufficiently disclose "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier," this element would have been obvious to a person having ordinary skill in the art because it is simply a restatement of the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as

of the ’988 patent’s priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 (“Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design.”); G.992.1, § 9.5.1 (“Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.”).

795. Thus, Chow discloses and/or renders obvious claim 16.i.

l. <u>Claim 16.j “wherein the first SNR margin is different than the second SNR margin,”</u>

796. Chow discloses and/or renders obvious “wherein the first SNR margin is different than the second SNR margin.”

797. As shown in the annotated versions of Figures 6.20, 6.22, 6.24, and 6.26, copied below, Chow discloses that the first SNR margin (for the first of carrier) is different from the second SNR margin (for the second carrier):

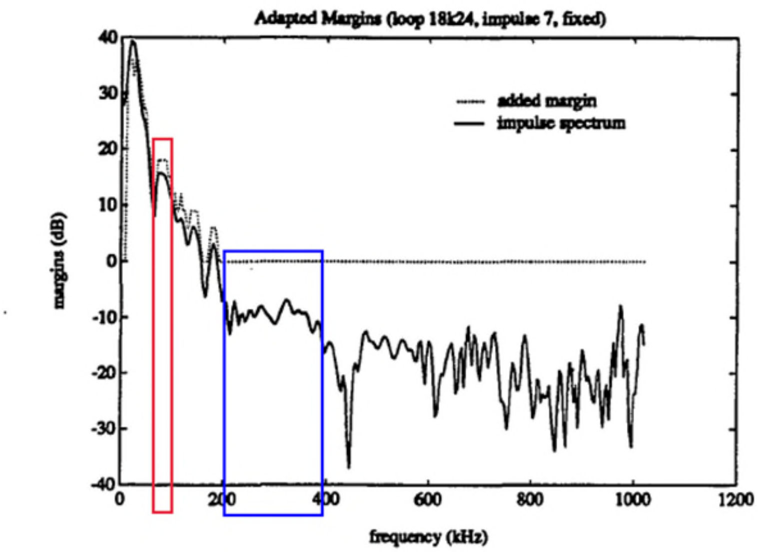


Figure 6.20: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Fixed Updates

Id. at Fig. 6.20 (annotated).

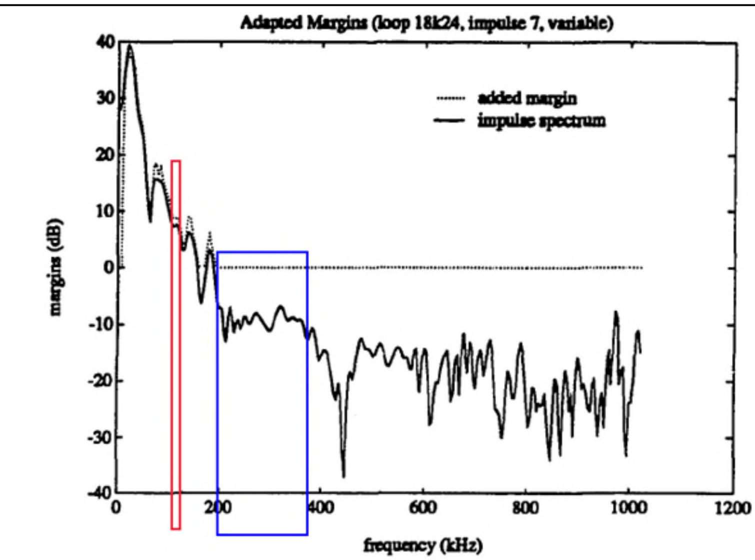


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22 (annotated).

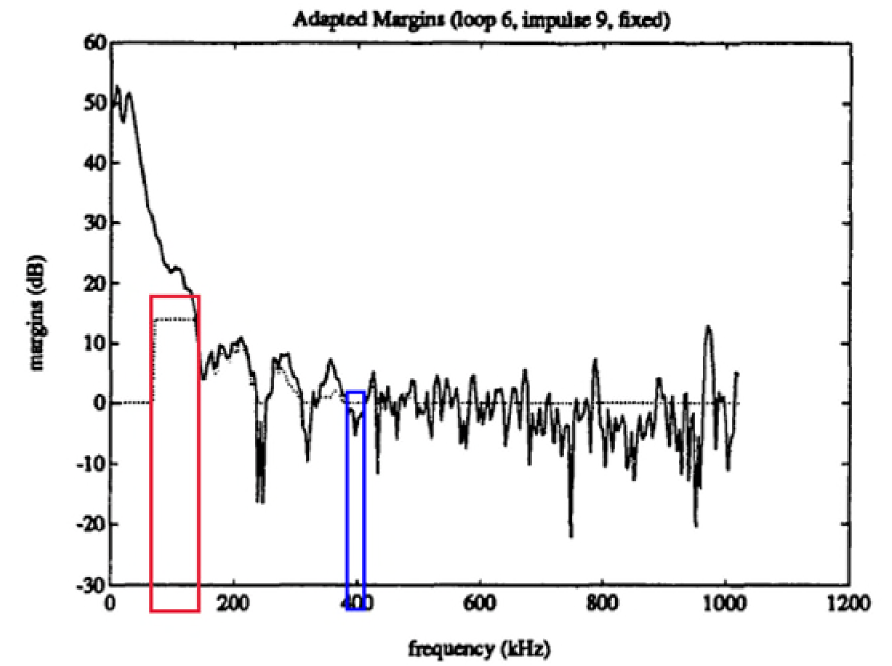


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24 (annotated).

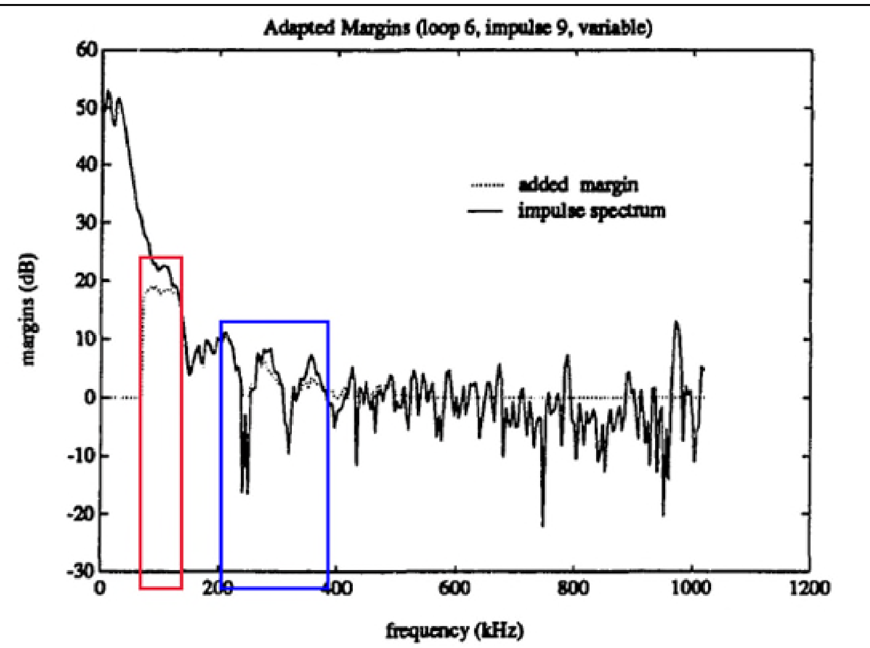


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26 (annotated).

798. Although I have called out in the annotations specific potential first and second carrier locations, any two carriers using different added margins qualify as the first and second carriers of claim 16, in which case the first SNR margin and the second SNR margin would be different.

799. "As is evident from the figure, this simple adaptation process will give additional margin to those tones most susceptible to the impulsive disturbance. . . . In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

800. Figure 6.22 indicates that updating the margins according to Equation (6.17) provides an improvement over adding fixed additional margin on each update. The resulting distribution of additional margin more closely follows the actual shape of the impulse spectrum than the margin distribution presented in Figure 6.20 for the case of constant updates. Furthermore, by comparing Figures 6.21 and 6.23, we find that the resulting bit distributions are indeed different for the two techniques. Figures 6.20 and 6.22 illustrate that the margin update process successfully increases the amount of error protection on those tones most susceptible to a particular impulse noise." *Id.*

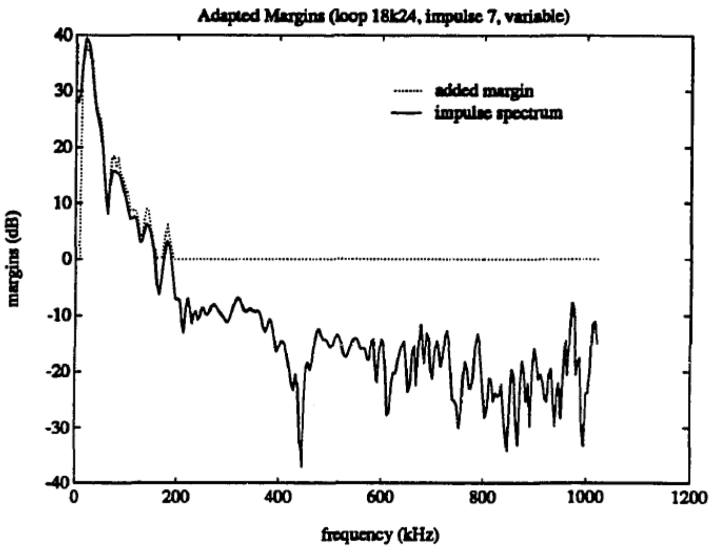


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

801. "The margins in this table represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157.

802. "Figures 6.24 to 6.27 present plots of the margin distributions and bit distributions obtained for the two margin update methods, respectively. The plots in Figures 6.24 and 6.26 further confirm that both techniques for adapting the margin distributions will result in increased margin on those tones most affected by impulse noise, and the technique that allows a range of margins to be added per update will provide better performance in terms of matching the distribution of additional margins to the actual shape of the impulse spectrum. We note that in this test scenario, carriers below 70 kHz are not used due to the lower bandedge of the system. However, there is still significant impulse noise energy in the frequency band available for transmission, and as is evident from the plots, there is not enough margin available to compensate

fully for the large degradation in error rate caused by the impulse noise in the lower frequency tones." *Id.* at 158-60.

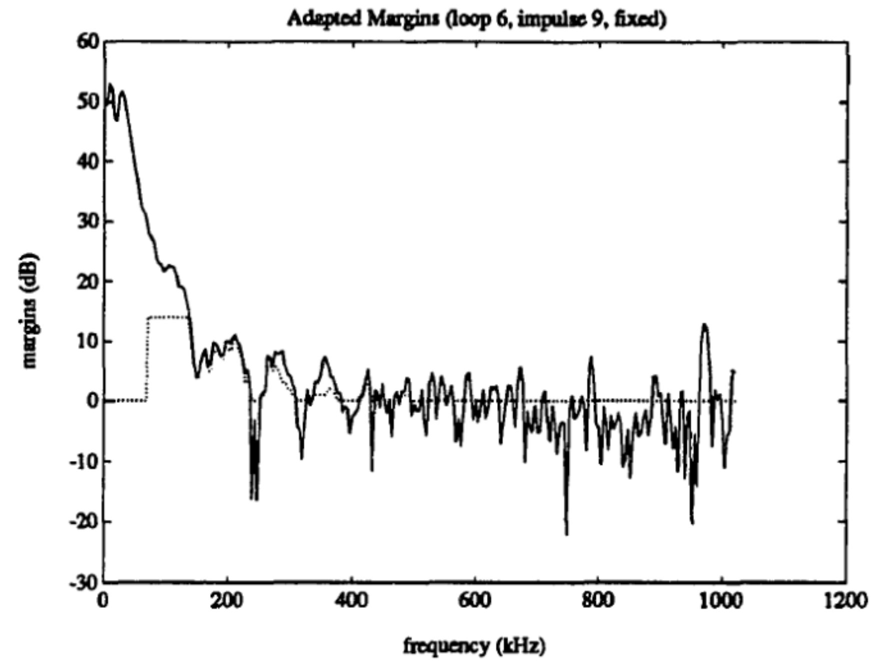


Figure 6.24: Margins for Loop 6 with Impulse 9 and Fixed Updates

Id. at Fig. 6.24.

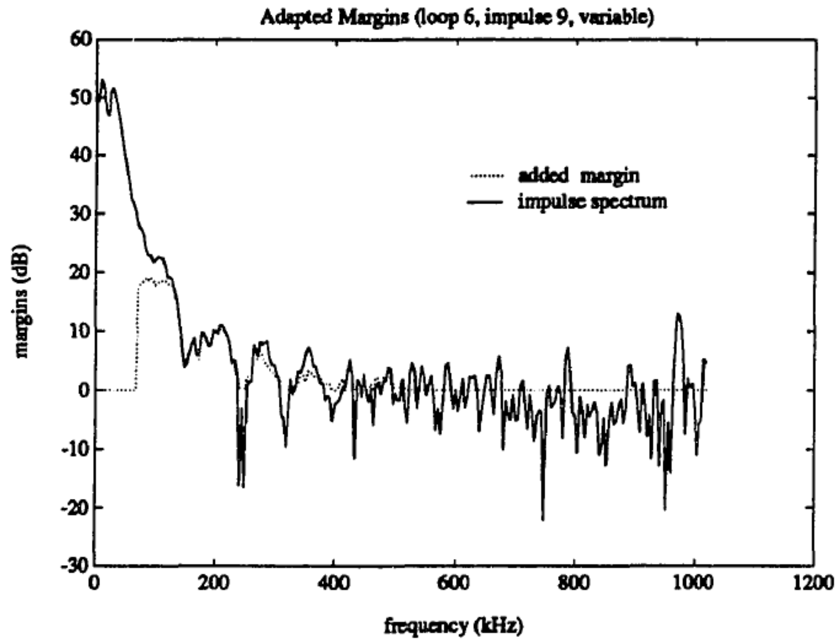


Figure 6.26: Margins for Loop 6 with Impulse 9 and Variable Updates

Id. at Fig. 6.26.

803. Thus, Chow discloses and/or renders obvious claim 16.j.

m. <u>Claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"</u>

804. Chow discloses and/or renders obvious "wherein the first SNR margin is different than the third SNR margin, and."

805. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

806. "As is evident from the figure, this simple adaptation process will give additional margin to those tones most susceptible to the impulsive disturbance. . . . In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

807. Figure 6.22 indicates that updating the margins according to Equation (6.17) provides an improvement over adding fixed additional margin on each update. The resulting distribution of additional margin more closely follows the actual shape of the impulse spectrum than the margin distribution presented in Figure 6.20 for the case of constant updates. Furthermore, by comparing Figures 6.21 and 6.23, we find that the resulting bit distributions are indeed different for the two techniques. Figures 6.20 and 6.22 illustrate that the margin update process successfully increases the amount of error protection on those tones most susceptible to a particular impulse noise." *Id.*

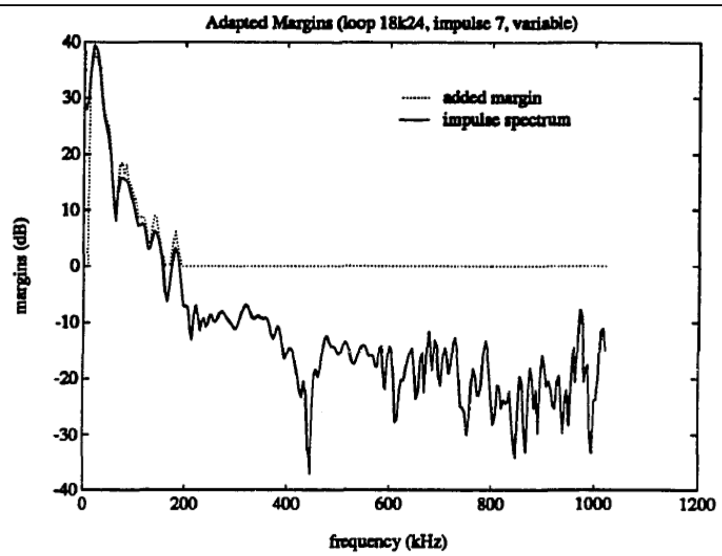


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

808. Chow also describes updating the added margins as additional impulse noise is detected. Chow teaches monitoring "the occurrence of a large number of unusually high error signals over the carriers in a DMT symbol" and using a threshold to decide whether "the error signal on a particular subchannel is 'unusually high.'" *Id.* at 151. When more than a threshold number of subchannels have been found to have unusually high error signals, Chow teaches that an impulse is likely to be present. *Id.* In response, "the estimate of the impulse spectrum is updated, using the mean squared error signals on all of the subchannels." *Id.* at 151-52. Chow defines a running sum, α_ij, which is the impulse spectral estimate on subchannel i at time j. *Id.* at 152. Chow also defines another threshold, impthresh, and teaches that after some number of suspected impulse occurrences, "additional margin will be given to those subchannels with mean squared error estimates, α_ij," that exceed impthresh. *Id.* Chow explains in detail how to determine how much additional margin to allocate to each subchannel whose mean squared error estimate, α_ij, exceeds impthresh, and Chow presents the results of multiple simulations illustrating the effect of the disclosed techniques. *See id.* at 152-61. Chow discloses that "[t]he effect of adding margin to some of the tones is to force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible, using the adaptive bit swap algorithm presented in Section 4.3.5." *Id.* at 153.

809. Chow also discloses that the technique of allocating additional margin to subchannels affected by impulse noise "continuously adapts both the transmitter and the receiver during normal system operation and adjusts the target system performance margin on a subchannel-by-subchannel basis." *Id.* at 165. Thus, Chow discloses that the first carrier uses a first SNR margin at a first time, and then, following the adaptation, the first carrier uses a second SNR margin that is different from the first SNR margin.

810. I incorporate by reference my analysis for claim limitations 16.b, 16.d and 16.f through 16.i.

811. Thus, Chow discloses and/or renders obvious claim 16.k.

n. Claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

812. Chow discloses and/or renders obvious "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

813. Chow discloses that

> DSL applications have generated a tremendous amount of research interest in designing ultra-high performance, yet cost effective, digital data transmission systems. Efficient modulation and equalization techniques are necessary in these transmission environments because of severe channel attenuation, intersymbol interference, and a host of other line impairments, including crosstalk, additive white Gaussian noise, and impulse noise. These highly challenging data transmission environments offer the ideal testing grounds for those digital communication techniques presented in the previous three chapters of this dissertation, and we will now focus on three particularly promising DSL applications; namely, the U.S. ADSL service, the European El-rate HDSL (El-HDSL) service, and the closely related Very High-speed Digital Subscriber Line (VHDSL) service.

Id. at 78.

814. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

815. "As is evident from the figure, this simple adaptation process will give additional margin to those tones most susceptible to the impulsive disturbance. . . . In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

816. Figure 6.22 indicates that updating the margins according to Equation (6.17) provides an improvement over adding fixed additional margin on each update. The resulting distribution of additional margin more closely follows the actual shape of the impulse spectrum than the margin distribution presented in Figure 6.20 for the case of constant updates. Furthermore, by comparing Figures 6.21 and 6.23, we find that the resulting bit distributions are indeed different for the two techniques. Figures 6.20 and 6.22 illustrate that the margin update process successfully increases the amount of error protection on those tones most susceptible to a particular impulse noise." *Id.*

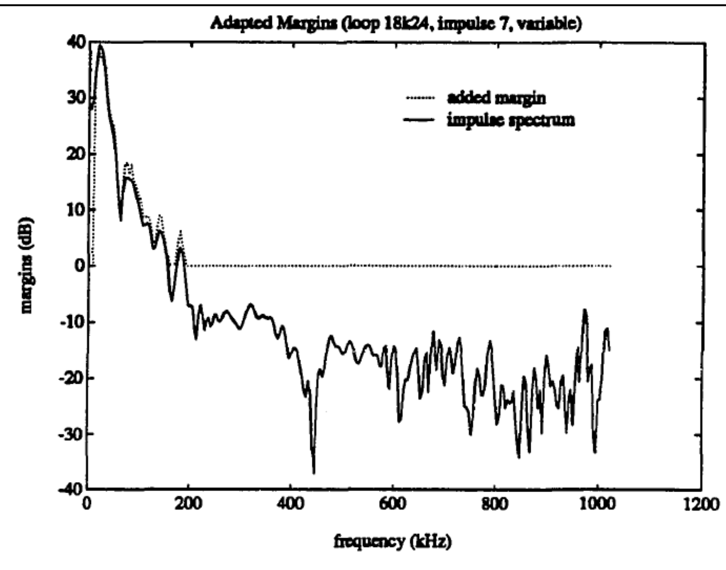


Figure 6.22: Margins for 18 kft, 24 AWG Loop with Impulse 7 and Variable Updates

Id. at Fig. 6.22.

817. I incorporate by reference my analysis for claim limitations 16.b, 16.d and 16.f through 16.i.

818. "The fundamental goal of all "multicarrier" modulation techniques is to partition a data transmission channel with ISI into a set of orthogonal, memoryless subchannels, each with its own "carrier." (*See* [23] and [24]). Data is transmitted through each subchannel independently of other subchannels, and within each subchannel, the channel response is (ideally) fiat, as long as the channel is partitioned sufficiently." *Id.* at 16-17. "Furthermore, different numbers of bits can be conveniently assigned to different subchannels. As a result, more data can be transmitted over those subchannels with larger SNR's and less data can be transmitted over those subchannels with smaller SNR's. In fact, no data will be transmitted over the worst portion of the frequency band if the received SNR over those subchannels cannot support the minimum number of bits at the required BER. In this manner, either the overall throughput or the system performance margin of the DMT system can be optimized." *Id.* at 20.

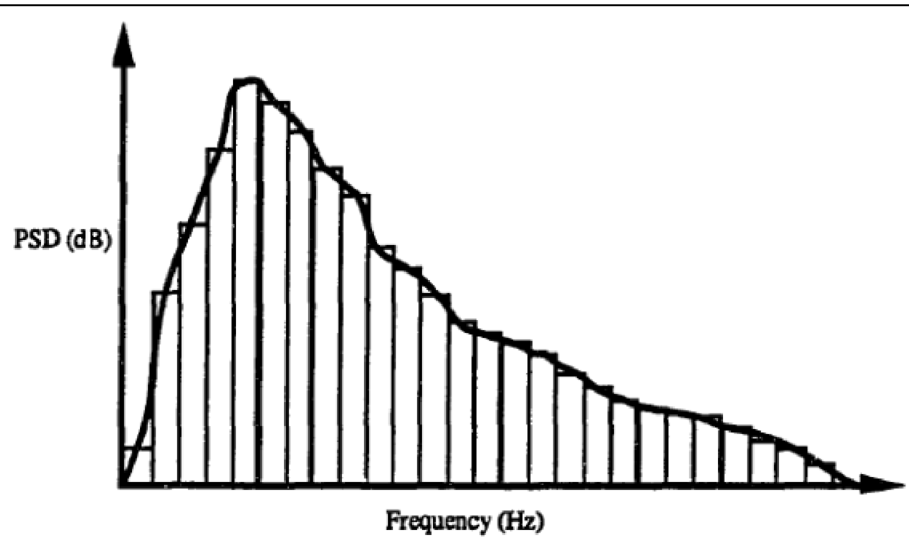


Figure 2.6: DMT Bit Allocation in the Frequency Domain

Id. at Fig. 2.6.

819. Similarly, since carriers are mentioned as distinct subchannels, distinguishing between the pluralities means there is more than one, thus there is a second and third carrier. Given a plurality of carriers, there is a plurality of bits that travel through the subchannels. "This assumption is the direct result of a perfectly flat energy distribution over all used carriers, or over the entire used portion of the transmission band, if we insist on equal probability of error for all used carriers. Because the Q-function (see Equation (2.13)) is not a linear function, the relationship between the input energy £ and the resulting probability of error P_e will not be linear either, and in the moderate to high SNR region; that is, SNR $\geq$ 10 dB, where most practical systems operate, the optimal solution for a multicarrier system can be shown to have virtually equal probability of error for all used subchannels. In other words, for two subchannels with moderate to high SNR's, the aggregate probability of error between them will be minimized if we force the two carriers to have the same P_e. From Equations (2.9), (2.10), and (2.11), we see that in order to maintain equal probability of error, or equivalently to keep the argument of the Q-function constant, we can either vary the input energy to each of the used carriers or vary the number of bits supported by each of the carriers." *Id.* at 64.

820. "The performance of this frequency domain clipping technique in general depends on the manner in which power is allocated among the carriers, the channel transfer function, and the actual number of carriers used." *Id.* at 143.

821. "[Figure 6.21] clearly demonstrates the ability of a DMT system to move bits from the lower carriers to the higher carriers in order to avoid the large low frequency content of the injected impulse noise. In some instances, the amount of margin required, after adaptation, for a particular carrier that is initially used for data transmission is large enough to force the system to stop using that particular carrier and redistribute those bits among other carriers." *Id.* at 155.

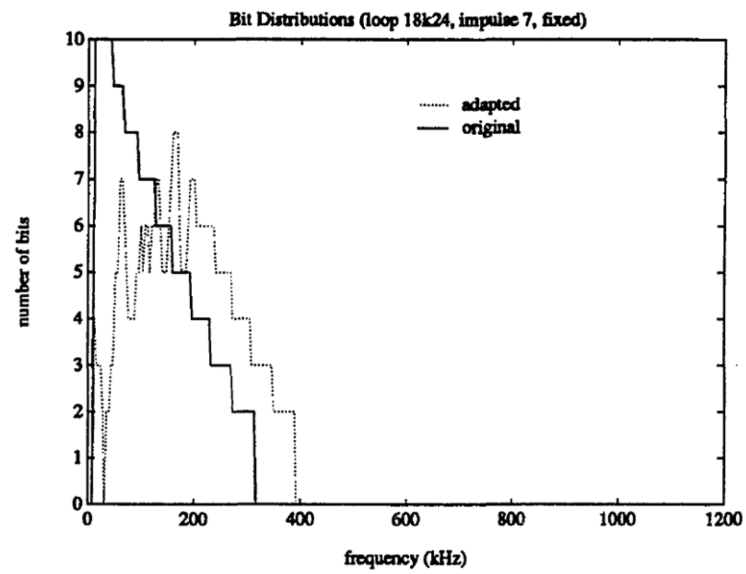


Figure 6.21: Bit Table for 18 kft, 24 AWG Loop, Impulse 7, and Fixed Updates

Id. at Figure 6.21.

822. "The margins in this table [6.15] represent the margins on those subchannels to which no additional margin is given and are important in determining the overall BER of the system in the absence of impulse noise." *Id.* at 157. The table shows multiple subchannels and the corresponding margins and tones.

Iteration Number	Fixed Margin: 3.0 dB		Variable Margin: 2.0-5.0 dB	
	Margin (dB)	Tones in Error	Margin (dB)	Tones in Error
1	28.0	318	28.0	312
2	27.0	241	26.8	220
3	26.1	219	25.6	213
4	25.1	206	24.5	197
5	24.3	197	23.6	167
6	23.4	169	22.7	130
7	22.8	146	21.9	100
8	22.2	127	21.2	97
9	21.7	115	20.8	17
10	21.1	92	20.4	0
11	20.7	67	–	–
12	20.2	34	–	–
13	19.9	8	–	–

Table 6.15: Margins and Number of Tones in Error for 18 kft, 24 AWG Loop with Impulse 7

Id. at Table 6.15.

823. To the extent it is determined that Chow does not sufficiently disclose that the first plurality of bits, the second plurality of bits, and the third plurality of bits are each different from one another, this element would have been obvious to a person having ordinary skill in the art. The transceiver described in Chow is a DMT transceiver. As would have been appreciated by those having ordinary skill in the art as of the priority date, a DMT transmitter processes data provided to it over a data interface and allocates different bits from the processed bit stream to different carriers for transmission. A DMT receiver then demodulates those different portions of the bit stream from the received carriers. Accordingly, the transceivers described in Chow are operable to demodulate for reception a first plurality of bits from a first carrier using a first Signal to Noise Ratio (SNR) margin and to demodulate for reception a second plurality of bits from a second carrier using a second SNR margin, and to demodulate for reception a third plurality of bits from the first carrier using a third SNR margin, wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

824. Thus, Chow discloses and/or renders obvious claim 16.l.

825. Consequently, Chow anticipates claim 16 and/or claim 16 would have been obvious to a person having ordinary skill in the art in view of Chow.

5. U.S. Patent No. 6,516,027 to Kapoor et al. ("Kapoor") In View of Chow

826. Kapoor in view of Chow renders obvious each element of claim 16 of the '988 Patent. I provided a brief description of Kapoor and Chow above. I incorporate that discussion by reference here.

a. Claim 16

827. In my opinion, the teachings of Kapoor in combination with the teachings of Chow would have rendered claim 16 of the ’988 patent obvious to a person having ordinary skill in the art.

b. Motivation to Combine Teachings of Kapoor with Teachings of Chow

828. In my opinion, a person having ordinary skill in the art would have been motivated to combine the teachings of Kapoor with the teachings of Chow as recited in claim 16 of the ’988 Patent and would have had a reasonable expectation of success in making the combination.

829. Kapoor’s objective is to provide bit loading (i.e., the allocation of bits to subcarriers) techniques that improve on prior art algorithms. *See, e.g.*, Kapoor at Abstract, 3:7-4:21. In its background section, Kapoor teaches that “[t]he margin is the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap,” where “[t]he SNR gap is measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel.” *Id.* at 2:24-33. Kapoor also states that “[t]he need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments.” *Id.* at 7:47-48.

830. A person having ordinary skill in the art would have understood the unforeseen additive noise impairments referred to by Kapoor to include, among other things, impulse noise because it was known as of the priority date that DSL channels suffer from impulse noise. For example, T1.413 Issue 1 defines tests for ADSL transceivers that include AWGN, crosstalk, and impulse noise. *See, e.g.*, T1.413 Issue 1, § 15.2.2 (“There are two impulse waveforms defined for testing. These are reconstructions of actual recorded impulses observed in field tests, and

represent the single most likely waveforms at specific sites."); *id.* at § 15.3.2 (defined test conditions include AWGN, crosstalk, and impulse noise, among others); *id.* at § 15.3.2.2 ("Impulse test" includes crosstalk interference set forth in tables in § 15.3.2.1, which tables say that "[t]he indicated interferers for each test are summed together with AWGN with PSD of -140 dBm/Hz to form a composite power spectral density."). *See also, e.g.*, COMMSCOPE072109 at COMMSCOPE072110 (D.647 (June 21-July 2, 1999)), § 6.2.2.1 ("The VDSL system is required to meet its reach and quality of service requirements with adequate margin (6 dB at 1e-7), considering crosstalk (*see* Section 6.2.1), impulse noise (*see* Section 6.2.3), system noise and broadband environmental noise (*see* Section 6.2.4) contributions, while at the same time the loop is subject to simultaneous RFI from multiple AM broadcast stations, and an adjacent amateur radio station."); COMMSCOPE072133 (D.748 (April 3-14, 2000)) at COMMSCOPE072136, COMMSCOPE072140-41 (distinguishing between performance with AWGN only and AWGN plus impulse noise). Accordingly, a person having ordinary skill in the art considering the communication systems of Kapoor would have known that impulse noise is a problem for DSL systems and would have been motivated to improve the robustness of Kapoor's communication systems in the presence of impulse noise.

831. Among other things, Chow's 187-page Ph.D. dissertation investigates techniques for improving the performance of DMT systems in the presence of impulse noise. Chow at 114-15. Chow notes that most practical communication systems are designed "with a built-in performance margin to take the detrimental effects of impulse noise into account." *Id.* at 114. Along similar lines, Kapoor states that prior art bit loading algorithms "do not support a bit allocation method which allows different subchannels to operate at different bit error rates or margins," but that it would be "desirable to have a method which can allocate bits to subchannels

based on a desired bit error rate, and further to be able to allow subchannels to operate at different bit error rates." Kapoor at 4:8-10, 17-21.

832. Kapoor teaches that its techniques allow different subchannels to "have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains. . . ." *Id.* at 8:39-42. Kapoor thus discloses that different margins can be used on different subchannels. But Kapoor does not describe in detail how to determine what the different margins on the different subchannels should be, or under what conditions the use of different margins on different subchannels might be advantageous. Accordingly, a person having ordinary skill in the art would have sought references addressing these shortcomings of Kapoor.

833. Chow teaches that the use of different margins on different subchannels can improve robustness in the presence of impulse noise. Specifically, Chow discloses that "[i]f the DMT transceiver can adaptively learn the spectral shape of the impulse noise and there is sufficient extra margin available, then the extra margin can be placed intelligently on those tones most susceptible to errors due to impulse noise." Chow at 114, 151. Thus, Chow teaches that the performance of a DMT system can be improved by detecting whether a subchannel is suffering from impulse noise and, if it is, allocating excess margin to that subchannel.

834. Chow teaches monitoring "the occurrence of a large number of unusually high error signals over the carriers in a DMT symbol" and using a threshold to decide whether "the error signal on a particular subchannel is 'unusually high.'" Chow at 151. When more than a threshold number of subchannels have been found to have unusually high error signals, Chow teaches that an impulse is likely to be present. *Id.* In response, "the estimate of the impulse spectrum is updated, using the mean squared error signals on all of the subchannels." *Id.* at 151-52. Chow defines a running sum, α_ij, which is the impulse spectral estimate on subchannel i at

time j. *Id.* at 152. Chow also defines another threshold, impthresh, and teaches that after some number of suspected impulse occurrences, "additional margin will be given to those subchannels with mean squared error estimates, α_ij," that exceed impthresh. *Id.* Chow explains in detail how to determine how much additional margin to allocate to each subchannel whose mean squared error estimate, α_ij, exceeds impthresh, and Chow presents the results of multiple simulations illustrating the effect of the disclosed techniques. *See id.* at 152-61

835. A person having ordinary skill in the art would have been motivated to improve the communication systems of Kapoor to improve robustness to impulse noise. In view of Kapoor's teaching that prior-art bit allocation techniques were suboptimal because they did not allow different subchannels to operate at different margins, a person having ordinary skill in the art would have been motivated to incorporate Chow's impulse-noise-detection and excess-margin-allocation techniques to the bit loading algorithms of Kapoor in order to improve system performance and overcome a drawback of the prior art specifically noted by Kapoor. As would have been appreciated by those having ordinary skill in the art as of the priority date, the result of applying Chow's teachings to the communication systems of Kapoor would be that different subchannels would have different margins, as Kapoor discloses would be desirable.

836. A person having ordinary skill in the art would thus have been motivated to add the impulse-noise-detection and excess-margin-allocation techniques of Chow to the communication devices of Kapoor, and would have found it trivial to do so. The disclosures of Chow are complementary to those of Kapoor, and it would have been obvious to a person having ordinary skill in the art to incorporate the teachings of Chow on how to allocate additional margin to subchannels suffering from impulse noise into the communication systems of Kapoor. Specifically, a skilled artisan would have used Chow's impulse-noise-detection and excess-

margin-allocation techniques to adjust the measured SNRs before running the bit loading algorithm, as taught by Kapoor. *See, e.g.*, Kapoor at 8:29-32. More specifically, Kapoor describes reducing the measured SNR of each subchannel by the difference between the margin and the coding gain (i.e., by the quantity γ_margin-γ_coding), and then determining the bit allocation and gain scaling values using the resulting reduced measured SNR values. *See, e.g., id.* at 7:43-10:46. Based on the teachings of Chow, a person having ordinary skill in the art would have been motivated to use impulse-noise-detection and excess-margin-allocation techniques to determine the additional margin for each subchannel, and then, as taught by Kapoor, to reduce each subchannel's measured SNR value by the value determined by Chow's techniques, because doing so would improve performance by providing more protection to subchannels known to be affected by impulse noise. In other words, a person having ordinary skill would have used, for a particular subchannel, the sum of the common margin (e.g., 6 dB) and the additional margin determined using Chow's impulse-noise-detection and excess-margin-allocation techniques as the γ_margin value to adjust the measured SNR of that subchannel in Kapoor's system before performing the bit allocation techniques of Kapoor. A skilled artisan would have found this modification trivial, particularly because Kapoor discloses that different margins can be used for different subchannels, and Chow teaches the use of higher margins on subchannels that are affected by impulse noise. Chow also teaches that the disclosed techniques are more attractive than alternatives because they "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible," which "is more desirable than merely increasing the transmit power applied to susceptible subchannels and decreasing the transmit power on other subchannels," which would "lead to a wide variation in the level of transmit power across the transmission band." Chow at 153. Thus, a person having ordinary skill

in the art would have recognized that adding the specific techniques of Chow to the communication systems of Kapoor would offer additional power advantages.

837. A person having ordinary skill in the art would have had a strong expectation of success in combining Chow's teachings (e.g., detecting subchannels affected by impulse noise and adding extra margin to each such subchannel prior to bit loading) with Kapoor's bit allocation procedures that allow the noise margin, error probability, and coding gain to vary from subchannel to subchannel. The addition of Chow's impulse-noise-detection and excess-margin-allocation techniques to the systems of Kapoor would have been trivial because Chow's impulse-noise-detection and excess-margin-allocation techniques and Kapoor's bit allocation techniques are complementary and fit together like pieces of a simple puzzle.

838. As explained in further detail below, combining the teachings of Chow with those of Kapoor as described herein would result in Kapoor's communication system including a multicarrier communications transceiver operable to demodulate for reception a first plurality of bits from a first carrier using a first SNR margin, and to demodulate for reception a second plurality of bits from a second carrier using a second SNR margin, and to demodulate for reception a third plurality of bits from the first carrier using a third SNR margin (wherein the first and second SNR margins are different and the first and third SNR margins are different, and wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another).

839. For example, Figures 6.20- 6.26 of Chow indicate that different carriers use different SNR margins, and each subchannel that carries any bits always carries two or more bits. Thus, the transceivers of Kapoor, modified as described herein by the teachings of Chow, are operable to demodulate for reception a first plurality of bits from a first carrier using a first SNR

margin and to demodulate for reception a second plurality of bits from a second carrier using a second SNR margin.

840. In addition, Kapoor and Chow both teach that as Showtime progresses, it may be necessary to make modifications. *See, e.g.*, Kapoor, 5:56-62 ("Once the training sequence is complete, the communication hardware shifts into the 'showtime' period in which actual data communications occur. Of course, even during this showtime period, the communication hardware can continue to monitor the line quality and adjust communication parameters as necessary."); *id.* at 6:15-20 ("Random access memory 14 is used, among other things, to store communications data, communication device operating programs, and measured parameters taken during the training and 'showtime' stages, including, for example, the measured signal-to-noise ratios for each subchannel."); Chow at 162 ("Along our development, we applied our proposed algorithms to specific DMT systems designed for advanced Digital Subscriber Line services, and in doing so, we realized that a continuously (that is, even after system initialization) adaptive transmitter is highly desirable, if not necessary, in these DSL transmission environments, where channels are in fact quasi-stationary and slowly time varying."); *id.* at 164-65 ("we presented a soft decision, multicarrier, error control technique that continuously adapts both the transmitter and the receiver during normal system operation and adjusts the target system performance margin on a subchannel-by-subchannel basis."). Accordingly, Kapoor and Chow in combination teach that the first carrier can use a first margin at one point in time and a third margin at another time.

841. As would have been understood by a person having ordinary skill in the art, the first plurality of bits received on the first carrier, the second plurality of bits received on the second carrier, and the third plurality of bits received (at a different time) on the first carrier would be

different from one another as recited by claim 16 because each plurality would be a different portion of the bit stream due to the operation of the DMT transceivers disclosed in Kapoor and Chow..

c. <u>Claim 16.pre “An apparatus comprising: a multicarrier communications transceiver”</u>

842. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, Kapoor discloses claim 16.pre “An apparatus comprising: a multicarrier communications transceiver.”

843. Kapoor discloses “A Method and Apparatus for Discrete Multitone Communication Bit Allocation.” Kapoor at Title. The invention in Kapoor “ relates to data communications, specifically to an apparatus and method for allocating bits among carrier tone subchannels (bins) in a discrete multitone modulation (DMT) communication system.” *Id.* at 1:7-11. There is an apparatus disclosed in Kapoor. “The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure that the received SNR in the i subchannel corresponds to bi bits in that subchannel.” *Id.* at 3:58-67.

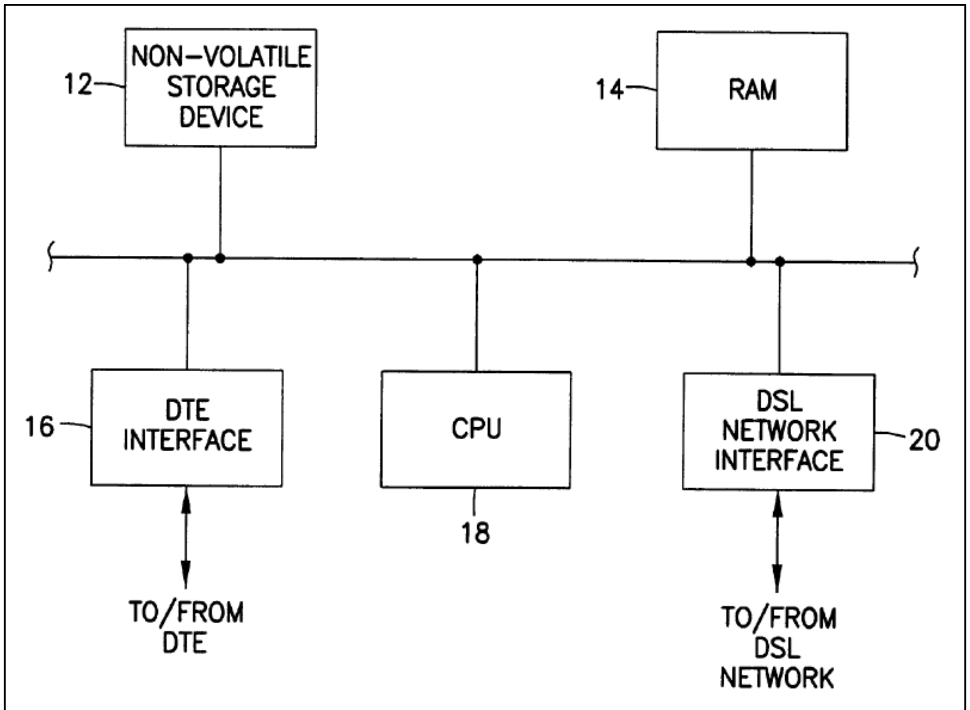


Fig. 2

Id. at Fig. 2.

844. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16.

845. Thus, Kapoor discloses the preamble of claim 16, to the extent it is limiting.

d. Claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier"

846. Kapoor discloses "operable to demodulate for reception a first plurality of bits from a first carrier."

847. "Subsequent DMT multicarrier modulation equipment made use of digital signal processing techniques including Fast Fourier Transforms and Inverse Fast Fourier Transforms. Digital signal processing allowed a single DMT communication device to be used to modulate all

subchannels, thereby improving reliability and lowering the cost of communications." *Id.* at 2:7-13.

848. "A preferred approach is to load each subchannel based on the individual transmission characteristics of that subchannel. Better subchannels, should carry more information than poorer quality subchannels. This allows an efficient use of the communication channel resources." *Id.* at 2:16-20.

849. "In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a corresponding plurality of respective bit values, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to-noise ratio values also correspond to the plurality of respective bit values. It is another object of the present invention to provide a method of allocating bits to a plurality of transmission subchannels in a communication system, in which a measuring step measures a signal-to-noise ratio for each of the plurality of transmission subchannels. An adjusting step adjusts the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain." *Id.* at 4:32-46.

850. "A processing unit determines a bit allocation value and again scaling factor for each of the plurality of transmission subchannels in accordance with the at least one stored bits to signal-to-noise ratio table." *Id.* at 4:60-63.

851. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16.

852. "Different subchannels therefore, can each have bit allocation values calculated based on different margins, different Pe/2 error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:39-42.

853. Kapoor also discloses that there are b_i bits in a subchannel after bit allocation has been completed, which means the multicarrier communications transceiver is operable to demodulate for reception a first plurality of bits from a first carrier. *Id.* at 3:64-67.

854. Thus, Kapoor discloses claim 16.a.

e. <u>Claim 16.b "using a first Signal to Noise Ratio (SNR) margin"</u>

855. Kapoor in view of Chow discloses that the multicarrier communications transceiver is operable to demodulate for reception the first plurality of bits from the first carrier "using a first Signal to Noise Ratio (SNR) margin."

> "Transmission channels are typically characterized by the channels margin, signal-to-noise ratio gap (hereinafter SNR gap), and capacity. All are related concepts. The margin is the amount of additional signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation scheme with a particular SNR gap. The SNR gap is a function of a chosen probability of transmission error and the modulation and coding techniques. The SNR gap measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel. The SNR gap is often constant over a wide range of transmission rates which may be transmitted by the particular modulation coding technique. The channel capacity refers to the maximum data rate capable of being transmitted on a particular channel. The optimum line coding technique has a SNR gap of zero dB. Although such an optimum line code requires infinite decoding/encoding delay and is infinitely complex, it has become practical at typical Digital Subscriber Line (DSL) speeds to implement modulation methods to achieve SNR gaps as low as 1-2 dB. Therefore, one factor to be considered during the bit allocation process is the transmission quality of each subchannel, in order to maximize the bit allocation for each subchannel."

Id. at 2:21-45.

856. "The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to-noise ratio in

accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory." *Id.* at 5:1-12.

857. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

858. Thus, Kapoor discloses claim 16.b.

859. I explained above (*see supra*, § XII.B.4.d) that Chow also discloses this element. I incorporate that explanation by reference here.

860. As I explained above (*see supra*, § X II.B.5.b which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor, 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow, 153.

861. Accordingly, Kapoor in view of Chow discloses claim 16.b.

f. Claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier"

862. Kapoor discloses "and to demodulate for reception a second plurality of bits from a second carrier."

863. "A processing unit determines a bit allocation value and again scaling factor for each of the plurality of transmission subchannels in accordance with the at least one stored bits to signal-to-noise ratio table." *Id.* at 4:59-62.

864. "Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:39-42.

865. Kapoor also discloses that there are b_i bits in a subchannel after bit allocation has been completed, which means the multicarrier communications transceiver is operable to demodulate for reception a second plurality of bits from a second carrier. *Id.* at 3:64-67.

866. Thus, Kapoor discloses claim 16.c.

867. I explained above (*see supra*, § X II.B.4.e) that Chow also discloses this element. I incorporate that explanation by reference here.

868. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins

would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

869. Thus, Kapoor in view of Chow discloses claim 16.c.

g. <u>Claim 16.d "using a second SNR margin"</u>

870. Kapoor in view of Chow discloses "using a SNR margin."

871. "The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory." *Id.* at 5:1-12.

872. I incorporate by reference my analysis for element 16.b.

873. Thus, Kapoor discloses claim 16.d.

874. I explained above (*see supra*, § XII.B.4.f) that Chow also discloses this element. I incorporate that explanation by reference here.

875. As I explained above (*see supra*, § XB.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would

"force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

h. Claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier"

876. Kapoor in view of Chow discloses "and to demodulate for reception a third plurality of bits from the first carrier."

877. "Although the above description is directed to a bit allocation process in which all subchannels are analyzed and bits allocated, an alternative embodiment exists in which the bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. For example, when the communication device has completed its training sequence and is operating in 'showtime', line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels." *Id.* at 11:35-42.

878. Kapoor also discloses that there are b_i bits in a subchannel after bit allocation has been completed, which means the multicarrier communications transceiver is operable to demodulate for reception a third plurality of bits from the first carrier. *Id.* at 3:64-67.

879. I also incorporate by reference my analysis for 16.a and 16.c.

880. Thus, Kapoor discloses claim 16.e.

881. I explained above (*see supra*, § XII.B.4.g) that Chow also discloses this element. I incorporate that explanation by reference here.

882. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of

Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

883. Thus, Kapoor in view of Chow discloses claim 16.e.

i. <u>Claim 16.f "using a third SNR margin"</u>

884. Kapoor discloses "using a third SNR margin."

885. "Once an SNR_{vec} and SNR_{maxvec} table has been stored for a particular number of bits, the process can be repeated to create a table for a different BER (step 28). Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:34-42.

886. "Also, because multiple tables corresponding to different $P_e/2$ values can be predetermined and stored, it is possible to allocate bits and establish gain scaling values for different subchannels using different P/2 values for those subchannels. For example, a $P_e/2$ value of 10^{-7} can be used to determine bit allocation and gain scaling for some subchannels, and a $P_e/2$ value of 10^{-8} can be used for the remaining subchannels. Of course, there is no limit to the number of different $P_e/2$ values which can be used, subject only the quantity of SNR tables stored in the communication device." *Id.* at 10:36-46.

887. "Within this inventive system and method, a framework is provided which also supports the use of different $P_e/2$ rates and SNR margins for different subchannels in a

communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55.

888. Kapoor also discloses that "[o]nce the training Sequence is complete, the communication hardware shifts into the 'showtime' period in which actual data communications occur. Of course, even during this showtime period, the communication hardware can continue to monitor the line quality and adjust communication parameters as necessary." *Id.* at 5:56-62. As would have been appreciated by a person having ordinary skill in the art as of the priority date, the adjusted communication parameters would include the SNR margin.

889. Kapoor further discloses that "when the communication device has completed its training sequence and is operating in 'showtime', line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels. Further, bit allocations for a subset of subchannels might be warranted during the training sequence based on a particular set of requirements or communication equipment operating conditions." *Id.* at 11:35-45. As would have been appreciated by a person having ordinary skill in the art as of the priority date, as a result of the re-executed bit allocation process, the margin on the first carrier could be different from its previous value.

890. I incorporate by reference my analysis for elements 16.b, 16.d, and 16.f.

891. Thus, the Kapoor discloses claim 16.f.

892. I explained above (*see supra*, § XII.B.4.h) that Chow also discloses this element. I incorporate that explanation by reference here.

893. As I explained above (*see supra*, § X B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153. For example, as modified by Chow, the transceiver of Kapoor would adjust the added margin values before performing the bit allocation process again. As a result, the margin used on the first carrier would be different from its previous value.

894. Thus, Kapoor in view of Chow discloses claim 16.f.

j. <u>Claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,"</u>

895. Kapoor discloses "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier."

> Transmission channels are typically characterized by the channels margin, signal-to-noise ratio gap (hereinafter SNR gap), and capacity. All are related concepts. The margin is the amount of additional Signal-to-noise ratio in excess of the minimum required to achieve a given performance level for a particular type of modulation Scheme with a particular SNR gap. The SNR gap is a function of a chosen probability of transmission error and the modulation and coding techniques. The SNR gap measures the inefficiency of the transmission method with respect to the best possible performance, assuming an additive white Gaussian noise channel. The SNR gap is often constant over a wide range of transmission rates which may be transmitted by the particular modulation coding technique. The channel capacity refers to the maximum data rate capable of being

> transmitted on a particular channel. The optimum line coding technique has a SNR gap of zero dB. Although such an optimum line code requires infinite decoding/encoding delay and is infinitely complex, it has become practical at typical Digital Subscriber Line (DSL) speeds to implement modulation methods to achieve SNR gaps as low as 1-2 dB. Therefore, one factor to be considered during the bit allocation process is the transmission quality of each subchannel, in order to maximize the bit allocation for each subchannel.

Id. at 2:21-45.

896. "The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure that the received SNR in the i subchannel corresponds to bi bits in that subchannel." *Id.* at 3:58-67.

897. "The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory." *Id.* at 5:1-12.

898. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

899. I incorporate by reference my analysis for elements 16.pre through 16.f.

900. To the extent it is determined that Kapoor does not sufficiently disclose "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier," this element would have been obvious to a person having ordinary skill in the art because it is simply a restatement of the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as of the '988 patent's priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

901. Thus, Kapoor discloses claim 16.g.

902. I explained above (*see supra*, § XII.B.4.i) that Chow also discloses this element. I incorporate that explanation by reference here.

903. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on

different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

904. Thus, Kapoor in view of Chow discloses claim 16.g.

k. Claim 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier,"

905. Kapoor in view of Chow discloses "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier."

906. "The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure that the received SNR in the i subchannel corresponds to bi bits in that subchannel." *Id.* at 3:58-67.

907. "The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission

subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory." *Id.* at 5:1-12.

908. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

909. I incorporate by reference my analysis for elements 16.pre through 16.g.

910. To the extent it is determined that Kapoor does not sufficiently disclose "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier," this element would have been obvious to a person having ordinary skill in the art because it is simply a restatement of the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as of the '988 Patent's priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

911. Thus, the Kapoor discloses claim 16.h.

912. I explained above (*see supra*, § XII.B.4.j) that Chow also discloses this element. I incorporate that explanation by reference here.

913. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

914. Accordingly, Kapoor in view of Chow discloses claim 16.h.

l. <u>Claim 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,"</u>

915. Kapoor discloses "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier."

916. "The detail behind the derivation of this equation is described below. Recall that the SNR gap depends on the type of modulation and coding used in a transmitter as well as the target bit error rate (BER). This same expression can be rewritten in order to express the SNR required to achieve a particular number of bits per subchannel. Because this expression must hold after bit allocation has been completed, gain scaling should be done at the transmitter to ensure that the received SNR in the i subchannel corresponds to bi bits in that subchannel." *Id.* at 3:58-67.

917. "The processing unit controls functions which measure a signal-to-noise ratio for each of the plurality of transmission subchannels, adjust the measured signal-to-noise ratio in

accordance with an SNR-margin and a coding gain, generate a plurality of signal-to-noise ratio difference values, select a bit allocation value for each of the plurality of transmission subchannels, the bit allocation value corresponding to one of the plurality of signal-to-noise ratio difference values, determine a gain scaling factor for each of the plurality of transmission subchannels, and store each of the bit allocation values and the gain scaling factors as one or more data structures in the memory." *Id.* at 5:1-12.

918. "The need for an SNR margin factor is motivated by the presence of unforeseen additive noise impairments. It represents the additional noise power in dB that would be required to increase the $P_e/2$ rate to the specified value, for example, 10^{-7}." *Id.* at 7:47-51.

919. I incorporate by reference my analysis for elements 16.pre through 16.h.

920. To the extent it is determined that Kapoor does not sufficiently disclose "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier," this element would have been obvious to a person having ordinary skill in the art because it is simply a restatement of the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as of the '988 Patent's priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS

FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

921. Thus, the Kapoor discloses claim 16.i.

922. I explained above (*see supra*, § XII.B.4.k) that Chow also discloses this element. I incorporate that explanation by reference here.

923. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

924. Thus, Kapoor in view of Chow discloses claim 16.i.

m. <u>Claim 16.j "wherein the first SNR margin is different than the second SNR margin,"</u>

925. Kapoor in view of Chow discloses "wherein the first SNR margin is different than the second SNR margin."

926. Kapoor discloses the contrast between SNR margins such that one can determine which is more robust. "Once an SNR_{vec} and SNR_{maxvec} table has been stored for a particular number of bits, the process can be repeated to create a table for a different BER (step 28). Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit

allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:34-42.

927. Moreover, Kapoor discloses that "because multiple tables corresponding to different $P_e/2$ values can be predetermined and stored, it is possible to allocate bits and establish gain scaling values for different subchannels using different P/2 values for those subchannels. For example, a $P_e/2$ value of 10^{-7} can be used to determine bit allocation and gain scaling for some subchannels, and a $P_e/2$ value of 10^{-8} can be used for the remaining subchannels. Of course, there is no limit to the number of different $P_e/2$ values which can be used, subject only the quantity of SNR tables stored in the communication device." *Id.* at 10:36-46.

928. "Within this inventive system and method, a framework is provided which also supports the use of different $P_e/2$ rates and SNR margins for different subchannels in a communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55.

929. Thus, the Kapoor discloses claim 16.j.

930. I explained above (*see supra*, § XII.B.4.l) that Chow also discloses this element. I incorporate that explanation by reference here.

931. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on

different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

932. Thus, Kapoor in view of Chow discloses claim 16.j.

n. <u>Claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"</u>

933. Kapoor discloses "wherein the first SNR margin is different than the third SNR margin, and."

934. Kapoor discloses the contrast between SNR margins such that one can determine which is more robust. "Once an SNR_{vec} and SNR_{maxvec} table has been stored for a particular number of bits, the process can be repeated to create a table for a different BER (step 28). Similarly, the process can be repeated to create a set of tables for a different SNR gap for a different line coding technique (step 30). Different subchannels therefore, can each have bit allocation values calculated based on different margins, different $P_e/2$ error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:34-42.

935. Moreover, Kapoor discloses that "because multiple tables corresponding to different $P_e/2$ values can be predetermined and stored, it is possible to allocate bits and establish gain scaling values for different subchannels using different P/2 values for those subchannels. For example, a $P_e/2$ value of 10^{-7} can be used to determine bit allocation and gain scaling for some subchannels, and a $P_e/2$ value of 10^{-8} can be used for the remaining subchannels. Of course, there is no limit to the number of different $P_e/2$ values which can be used, subject only the quantity of SNR tables stored in the communication device." *Id.* at 10:36-46.

936. "Within this inventive system and method, a framework is provided which also supports the use of different Pe/2 rates and SNR margins for different subchannels in a communication line, and a process for allocating bits and gain scaling less than the entirety of subchannels." *Id.* at 11:51-55.

937. Kapoor also discloses that "[o]nce the training Sequence is complete, the communication hardware shifts into the 'showtime' period in which actual data communications occur. Of course, even during this showtime period, the communication hardware can continue to monitor the line quality and adjust communication parameters as necessary." *Id.* at 5:56-62. As would have been appreciated by a person having ordinary skill in the art as of the priority date, the adjusted communication parameters would include the SNR margin.

938. Kapoor further discloses that "when the communication device has completed its training sequence and is operating in 'showtime', line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels. Further, bit allocations for a subset of subchannels might be warranted during the training sequence based on a particular set of requirements or communication equipment operating conditions." *Id.* at 11:35-45. As would have been appreciated by a person having ordinary skill in the art as of the priority date, as a result of the re-executed bit allocation process, the margin on the first carrier could be different from its previous value.

939. Thus, the Kapoor discloses claim 16.k.

940. I explained above (*see supra*, § XII.B.4.m) that Chow also discloses this element. I incorporate that explanation by reference here.

941. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153. For example, as modified by Chow, the transceiver of Kapoor would adjust the added margin values before performing the bit allocation process again. As a result, the margin used on the first carrier would be different from its previous value.

942. Accordingly, Kapoor in view of Chow discloses claim 16.k.

o. <u>Claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."</u>

943. Kapoor in view of Chow discloses "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

944. "Subsequent DMT multicarrier modulation equipment made use of digital signal processing techniques including Fast Fourier Transforms and Inverse Fast Fourier Transforms. Digital signal processing allowed a single DMT communication device to be used to modulate all subchannels, thereby improving reliability and lowering the cost of communications." *Id.* at 2:7-13.

945. "A preferred approach is to load each subchannel based on the individual transmission characteristics of that subchannel. Better subchannels, should carry more

information than poorer quality subchannels. This allows an efficient use of the communication channel resources." *Id.* at 2:16-20.

946. "In accordance with this method, the stored table is comprised of a plurality of minimum signal-to-noise ratio values and a corresponding plurality of respective bit values, the minimum signal-to-noise ratio values being determined in accordance with a maximum allowable gain scaling factor, wherein the signal-to-noise ratio values also correspond to the plurality of respective bit values. It is another object of the present invention to provide a method of allocating bits to a plurality of transmission subchannels in a communication system, in which a measuring step measures a signal-to-noise ratio for each of the plurality of transmission subchannels. An adjusting step adjusts the measured signal-to-noise ratio in accordance with an SNR-margin and a coding gain." *Id.* at 4:32-46.

947. "Data terminal equipment interface 16 and DSL network interface 20 are used to send and receive data to and from data terminal equipment and a DSL network, respectively." *Id.* at 6:13-16. "Different subchannels therefore, can each have bit allocation values calculated based on different margins, different Pe/2 error rates, and different coding gains, subject to the quantity of tables stored in the communication device 10." *Id.* at 8:39-42.

948. "Although the above description is directed to a bit allocation process in which all subchannels are analyzed and bits allocated, an alternative embodiment exists in which the bit allocation process is completed for a subset of subchannels, with the process not being completed for the remaining subchannels. For example, when the communication device has completed its training sequence and is operating in 'showtime', line degradation might lower the signal-to-noise ratios for certain subchannels such that the bit allocation process might need to be executed, and

the bit allocation forwarding table and the gain scaling table updated to reflect the new bit allocations for the selected subchannels." *Id.* at 11:35-42.

949. Kapoor also discloses that "As shown in FIG. 1, a data stream would enter a serial to parallel signal splitter 2 whose output would feed a plurality of modems 4." *Id.* at 1:53-55.

950. I incorporate by reference my analysis for elements 16.pre through 16.k.

951. To the extent it is determined that Kapoor does not sufficiently disclose that the first plurality of bits, the second plurality of bits, and the third plurality of bits are each different from one another, this element would have been obvious to a person having ordinary skill in the art. The transceivers described in Kapoor are DMT transceivers. As would have been appreciated by those having ordinary skill in the art as of the priority date, a DMT transmitter processes data provided to it over a data interface and allocates different bits from the processed bit stream to different carriers for transmission. A DMT receiver then demodulates those different portions of the bit stream from the received carriers. Accordingly, the transceivers described in Kapoor are operable to demodulate for reception a first plurality of bits from a first carrier using a first Signal to Noise Ratio (SNR) margin and to demodulate for reception a second plurality of bits from a second carrier using a second SNR margin, and to demodulate for reception a third plurality of bits from the first carrier using a third SNR margin, wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

952. Thus, the Kapoor discloses claim 16.l.

953. I explained above (*see supra*, § XII.B.4.n) that Chow also discloses this element. I incorporate that explanation by reference here.

954. As I explained above (*see supra*, § XII.B.5.b, which I incorporate by reference here), a person having ordinary skill in the art would have been motivated to add Chow's impulse-

noise-detection and excess-margin-allocation techniques to the communication systems of Kapoor in order to improve the performance of Kapoor's systems in the presence of impulse noise, which was known to be problematic for DSL systems. As a result of the combination, Kapoor's bit allocation algorithm would determine "bit allocation values calculated based on different margins" as taught by Kapoor, (Kapoor at 8:39-40), and the use of the different margins would "force a change in the bit distribution by moving bits from carriers most affected by impulse noise to those tones less susceptible" as taught by Chow. Chow at 153.

955. Consequently, claim 16 would have been obvious to a person having ordinary skill in the art in view of Kapoor.

956. Kapoor in view of Chow discloses each element of claim 16 of the '988 Patent.

6. TNETD8000 Very High Bit-Rate Digital Subscriber Line (VDSL) Chipset Hardware and Software Evaluation Module (EVM) User's Guide, TEXAS INSTRUMENTS, November 1999 ("TNETD8000 User Guide")

957. TNETD8000 User Guide discloses each element of claim 16 of the '988 Patent.

a. Claim 16

958. Claim 16 of the '988 Patent is anticipated by and/or would have been obvious to a person having ordinary skill in the art in view of TNETD8000 User Guide.

959. I note at the outset that claim 16 does not require the recited multicarrier communications transceiver to be operable to demodulate the first plurality of bits from the first carrier using the first SNR margin at the same time it demodulates the second plurality of bits from the second carrier using the second SNR margin and/or at the same time it demodulates the third plurality of bits from the first carrier using the third SNR margin.

960. I also note that the clauses "wherein the first/second/third SNR margin specifies a first/second/third value for an allowable increase in noise without an increase in the bit error rate

(BER) associated with the first/second/first carrier" simply restate the definition of SNR margin provided by the ADSL standards that were in existence and well known in the art as of the '988 Patent's priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

961. Accordingly, any apparatus comprising a multicarrier communications transceiver with a programmable or adjustable SNR margin would be operable to do what is recited in claim 16. Such a transceiver would be operable to receive data at a first time using a first SNR margin, and to receive data at a second time using a second SNR margin, and to receive data at a third time using a third SNR margin.

962. The TNETD8000 User Guide describes exactly such a multicarrier communications transceiver.

b. Claim 16.pre "An apparatus comprising: a multicarrier communications transceiver"

963. I understand that CommScope and Nokia do not concede that the preamble is limiting. To the extent that the preamble is limiting, TNETD8000 User Guide discloses claim 16.pre "An apparatus comprising: a multicarrier communications transceiver."

964. The apparatus contains a communications transceiver. "This document describes the management interface evaluation software and hardware used to configure, control, and

evaluate the TNETD8000 evaluation modem (EVM). . . . The TNETD8000 very-high-speed digital subscriber-line (VDSL) modem is a VDSL transceiver that enables high bit-rate data transmission on existing twisted-pair lines, while simultaneously supporting plain old telephone service (POTS) or integrated-services digital network (ISDN) service on the same lines. When asymmetric digital subscriber line (ADSL) loops reside in the same binder, the TNETD8000 EVM can be configured to ensure spectral compatibility with ADSL. The TNETD8000 EVM can support cumulative (upstream plus downstream) bit rates up to 60 Mbit/s in both symmetric and asymmetric configurations. The TNETD8000 EVM uses discrete multitone (DMT) modulation." TNETD8000 User Guide at iii.

965. Thus, the TNETD8000 User Guide discloses the preamble of claim 16, to the extent it is limiting.

c. Claim 16.a "operable to demodulate for reception a first plurality of bits from a first carrier"

966. TNETD8000 User Guide discloses "operable to demodulate for reception a first plurality of bits from a first carrier."

967. "The TNETD8000 very-high-speed digital subscriber-line (VDSL) modem is a VDSL transceiver that enables high bit-rate data transmission on existing twisted-pair lines, while simultaneously supporting plain old telephone service (POTS) or integrated-services digital network (ISDN) service on the same lines. . . . The TNETD8000 EVM can support cumulative (upstream plus downstream) bit rates up to 60 Mbit/s in both symmetric and asymmetric configurations. The TNETD8000 EVM uses discrete multitone (DMT) modulation." *Id.*

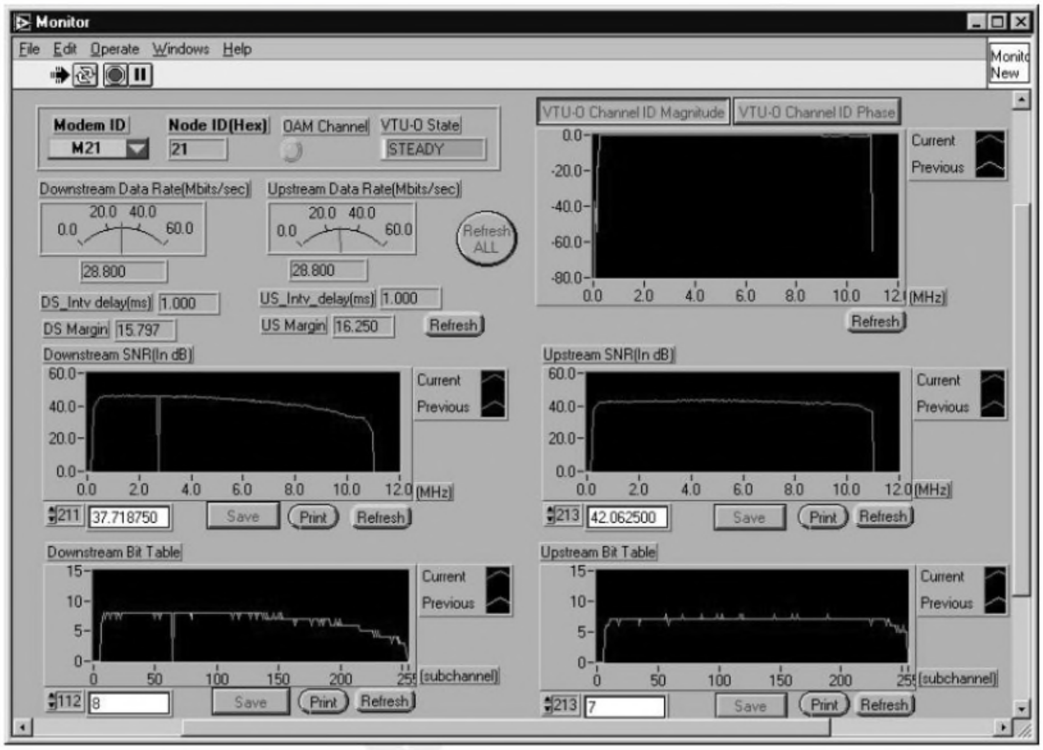
968. "Very-high-speed digital subscriber-line central office and remote transceiver units (VTU-O and VTU-R) are configured and transmission is initiated, monitored, and terminated through the TNETD8000 application software." *Id.* at 1-1.

969. "Graphs of the downstream and upstream SNRs, downstream and upstream bit distributions (per subchannel), and the channel magnitude and phase are available by clicking on the Refresh button next to the appropriate graph. The subchannel frequency (0 MHz to 11.04 MHz for FS, and 0 MHz to 5.52 MHz for ER) is listed along the horizontal X-axis for SNR and channel-magnitude/phase graphs. The frequency subchannel index (0–255) is listed along the horizontal X-axis for bits-per-subchannel graphs. Subchannel 255 (not used) corresponds in frequency to one-half the sampling rate." *Id.* at 7-4.

970. "The monitoring window retrieves and displays connection rates, SNR graphs, bit-loading graphs, etc. Once an active VDSL connection is established, click on the individual refresh buttons or the Refresh All button to see performance information (see Figure 7–1)." *Id.* at 7-2.

971. Figure 7-1 shows the Monitor Screen which shows SNR margins ("DS Margin" for the downstream direction, "US Margin" for the upstream direction), downstream data rates and bit table, upstream data rate and bit table, and other relevant data.

Figure 7–1. Monitor Screen



Id. at Figure 7-1.

972. The TNETD8000 User Guide discloses that the downstream and upstream SNR margins are configurable and can be set to at least three values (0 dB, 3 dB, 15 dB): "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common

value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10.

973. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

974. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

975. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt

box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

976. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

977. "7.1.3 Margin Indicators The DS Margin and US Margin indicators are located below the Upstream Data Rate (Mbits/sec) indicator. The actual noise margins are displayed separately for the DS and US directions. Click on the Refresh button to get the values for the connection. Margins are in dB." *Id.* at 7-4.

978. Thus, TNETD8000 User Guide discloses claim 16.a.

d. Claim 16.b "using a first Signal to Noise Ratio (SNR) margin"

979. The TNETD8000 User Guide discloses that the multicarrier communications transceiver is operable to demodulate for reception a first plurality of bits "using a first Signal to Noise Ratio (SNR) margin."

980. The TNETD8000 User Guide discloses that the downstream and upstream SNR margins are configurable and can be set to at least three values (0 dB, 3 dB, 15 dB), any one of which is a first SNR margin: "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins

control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10. With the "DS Margin" and/or "US Margin" set to this first value (*e.g.*, a selected one of 0 dB, 3 dB, or 15 dB), the disclosed multicarrier communications transceiver is operable to demodulate for reception a first plurality of bits from a first carrier using a first SNR margin (*i.e.*, demodulating two or more bits transmitted over any selected carrier *i* of the up to 256 carriers being received).

981. Table 5-3 contains information about target margins and target controls.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

982. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

983. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the

margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

984. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

985. "7.1.3 Margin Indicators The DS Margin and US Margin indicators are located below the Upstream Data Rate (Mbits/sec) indicator. The actual noise margins are displayed separately for the DS and US directions. Click on the Refresh button to get the values for the connection. Margins are in dB." *Id.* at 7-4.

986. Thus, TNETD8000 User Guide discloses claim 16.b.

e. Claim 16.c "and to demodulate for reception a second plurality of bits from a second carrier"

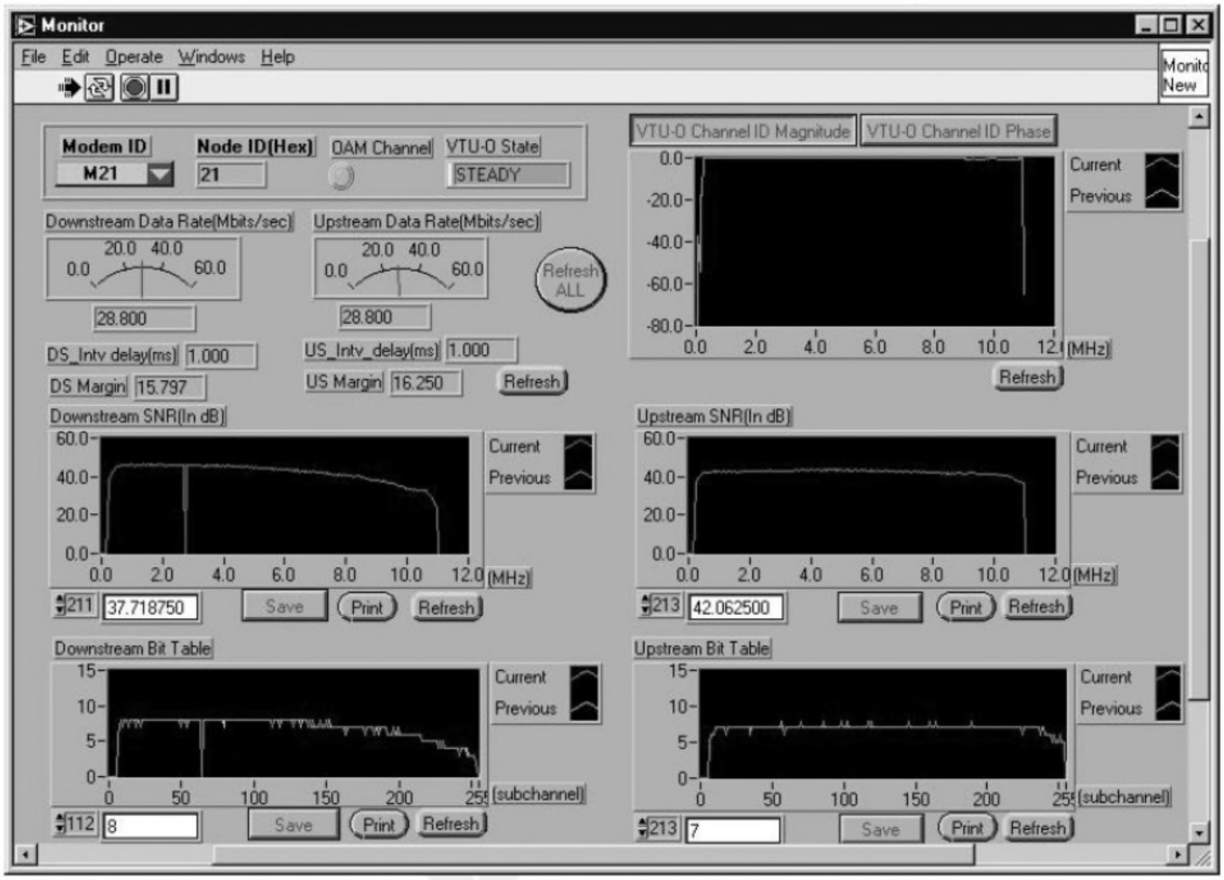
987. TNETD8000 User Guide discloses "and to demodulate for reception a second plurality of bits from a second carrier."

988. "Graphs of the downstream and upstream SNRs, downstream and upstream bit distributions (per subchannel), and the channel magnitude and phase are available by clicking on the Refresh button next to the appropriate graph. The subchannel frequency (0 MHz to 11.04 MHz for FS, and 0 MHz to 5.52 MHz for ER) is listed along the horizontal X-axis for SNR and channel-magnitude/phase graphs. The frequency subchannel index (0–255) is listed along the horizontal X-axis for bits-per-subchannel graphs. Subchannel 255 (not used) corresponds in frequency to one-half the sampling rate." *Id.* at 7-4.

989. "The monitoring window retrieves and displays connection rates, SNR graphs, bit-loading graphs, etc. Once an active VDSL connection is established, click on the individual refresh buttons or the Refresh All button to see performance information (*see* Figure 7–1)." *Id.* at 7-2.

990. Figure 7-1 depicts a monitor screen displaying a variety of information including Downstream Margins, Downstream SNR, Downstream Bit Table, Upstream SNR, and Upstream Bit Table.

Figure 7–1. Monitor Screen



Id. at Figure 7-1.

991. “5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10–7 in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10–7. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization

do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." Id. at 5-10.

992. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

993. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

994. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt

box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

995. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." Id.

996. "7.1.3 Margin Indicators The DS Margin and US Margin indicators are located below the Upstream Data Rate (Mbits/sec) indicator. The actual noise margins are displayed separately for the DS and US directions. Click on the Refresh button to get the values for the connection. Margins are in dB." *Id.* at 7-4.

997. Thus, TNETD8000 User Guide discloses claim 16.c.

f. <u>Claim 16.d "using a second SNR margin"</u>

998. The TNETD8000 User Guide discloses that the multicarrier communications transceiver is operable to demodulate for reception a second plurality of bits "using a second SNR margin."

999. The TNETD8000 User Guide discloses that the downstream and upstream SNR margins are configurable and can be set to at least three values (0 dB, 3 dB, 15 dB): "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service

in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10. As set forth above, any one of these at least three values (*e.g.*, 0 dB, 3 dB, 15 dB) is a first SNR margin, which leaves at least two remaining SNR margins, either of which can be the second SNR margin. With the "DS Margin" and/or "US Margin" set to this second value, the disclosed multicarrier communications transceiver is operable to demodulate for reception a second plurality of bits from a second carrier using a second SNR margin (*i.e.*, demodulating two or more bits transmitted over any carrier, other than the carrier *i*, of the up to 256 carriers being received).

1000. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1001. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

1002. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate

and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

1003. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

1004. "7.1.3 Margin Indicators The DS Margin and US Margin indicators are located below the Upstream Data Rate (Mbits/sec) indicator. The actual noise margins are displayed separately for the DS and US directions. Click on the Refresh button to get the values for the connection. Margins are in dB." *Id.* at 7-4.

1005. Thus, TNETD8000 User Guide discloses claim 16.d.

g. Claim 16.e "and to demodulate for reception a third plurality of bits from the first carrier"

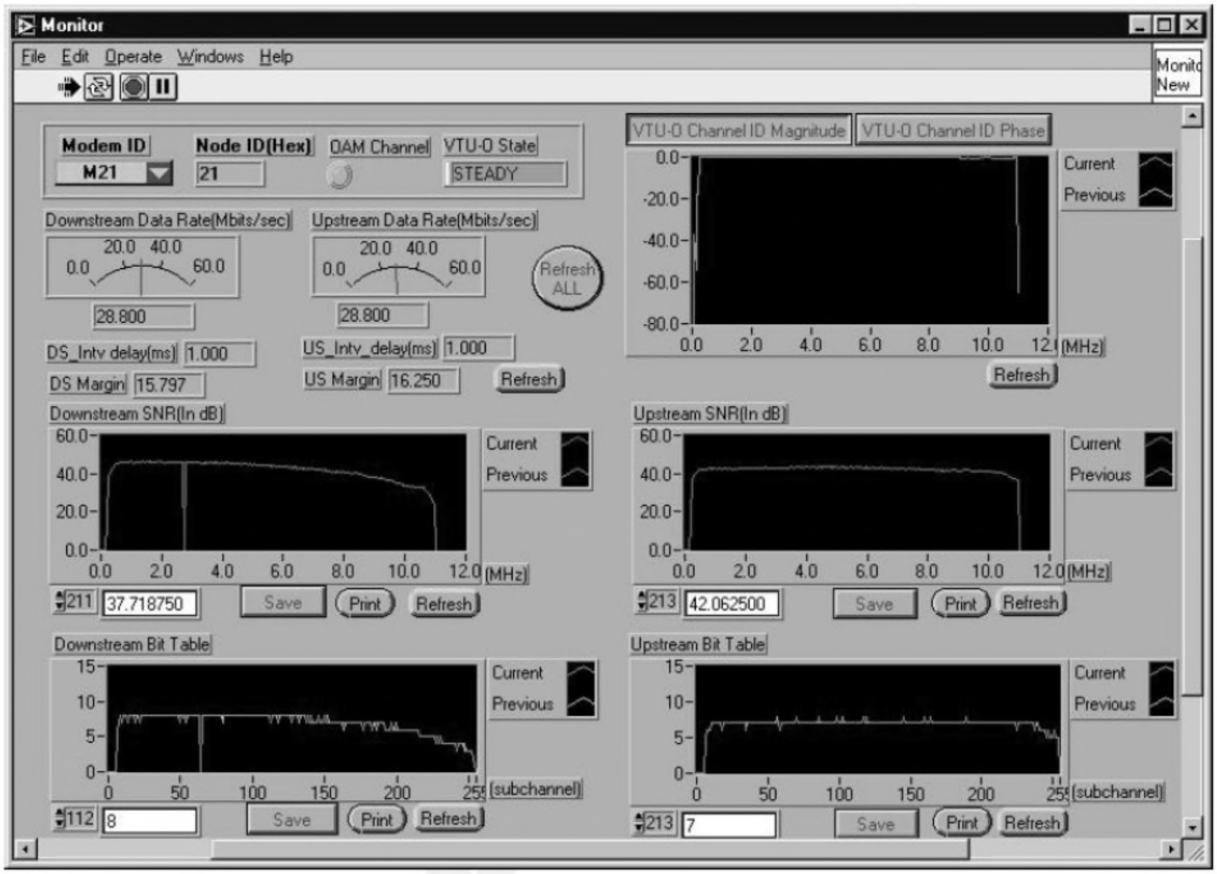
1006. The TNETD8000 User Guide discloses that the multicarrier communications transceiver is operable "to demodulate for reception a third plurality of bits from the first carrier."

1007. "Graphs of the downstream and upstream SNRs, downstream and upstream bit distributions (per subchannel), and the channel magnitude and phase are available by clicking on the Refresh button next to the appropriate graph. The subchannel frequency (0 MHz to 11.04 MHz for FS, and 0 MHz to 5.52 MHz for ER) is listed along the horizontal X-axis for SNR and channel-magnitude/phase graphs. The frequency subchannel index (0–255) is listed along the horizontal X-axis for bits-per-subchannel graphs. Subchannel 255 (not used) corresponds in frequency to one-half the sampling rate." *Id.* at 7-4.

1008. "The monitoring window retrieves and displays connection rates, SNR graphs, bit-loading graphs, etc. Once an active VDSL connection is established, click on the individual refresh buttons or the Refresh All button to see performance information (see Figure 7–1)." *Id.* at 7-2.

1009. Figure 7-1 shows the Monitor Screen which shows SNR margins, downstream bits, and other relevant data.

Figure 7–1. Monitor Screen



Id. at Figure 7-1.

1010. "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization

do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10.

1011. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1012. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

1013. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt

box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

1014. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

1015. "7.1.3 Margin Indicators The DS Margin and US Margin indicators are located below the Upstream Data Rate (Mbits/sec) indicator. The actual noise margins are displayed separately for the DS and US directions. Click on the Refresh button to get the values for the connection. Margins are in dB." *Id.* at 7-4.

1016. Thus, TNETD8000 User Guide discloses claim 16.e.

h. Claim 16.f "using a third SNR margin"

1017. The TNETD8000 User Guide discloses that the multicarrier communications transceiver is operable to demodulate for reception a third plurality of bits "using a third SNR margin."

1018. "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection

is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10. As set forth above, any one of these at least three values (*e.g.*, 0 dB, 3 dB, 15 dB) is a first SNR margin, and either of the remaining two values can be the second SNR margin, leaving one value as the third SNR margin. With the "DS Margin" and/or "US Margin" set to this third value, the disclosed multicarrier communications transceiver is operable to demodulate for reception a third plurality of bits from the first carrier (*i.e.*, carrier *i*) using a third SNR margin.

1019. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1020. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

1021. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64

kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

1022. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

1023. "7.1.3 Margin Indicators The DS Margin and US Margin indicators are located below the Upstream Data Rate (Mbits/sec) indicator. The actual noise margins are displayed separately for the DS and US directions. Click on the Refresh button to get the values for the connection. Margins are in dB." *Id.* at 7-4.

1024. Thus, the TNETD8000 User Guide discloses claim 16.f.

i. <u>Claim 16.g "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier,"</u>

1025. The TNETD8000 User Guide discloses "wherein the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier."

1026. "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10.

1027. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1028. To the extent it is determined that the TNETD8000 User Guide does not sufficiently disclose this element, it would have been obvious to a person having ordinary skill in the art that "the first SNR margin specifies a first value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the first carrier" based on the definition of SNR margin provided in the prevailing ADSL standards in force as of the priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is

designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

1029. Thus, TNETD8000 User Guide discloses claim 16.g.

j. <u>Claim 16.h "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier,"</u>

1030. The TNETD8000 User Guide discloses "wherein the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier."

1031. "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10.

1032. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1033. To the extent it is determined that the TNETD8000 User Guide does not sufficiently disclose this element, it would have been obvious to a person having ordinary skill in the art that "the second SNR margin specifies a second value for an allowable increase in noise without an increase in the bit error rate (BER) associated with the second carrier" based on the definition of SNR margin provided in the prevailing ADSL standards in force as of the priority date. *See, e.g.*, T1.413 Issue 1, § 11.2.2.1 ("Signal-to-Noise ratio (snr) margin: An snr margin primitive represents the amount of increased noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g., Trellis code, FEC) gains included in the design."); G.992.1, § 9.5.1 ("Signal-to-Noise Ratio (SNR) margin: The signal-to-noise ratio margin represents the amount of increased received noise (in dB) relative to the noise power that the system is designed to tolerate and still meet the target BER of 10^{-7}, accounting for all coding (e.g. trellis coding, RS FEC) gains included in the design. The SNR margin ranges from –64.0 dB to +63.5 dB with 0.5 dB steps.").

1034. Thus, the TNETD8000 User Guide discloses claim 16.h.

k. <u>Claim 16.i "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier,"</u>

1035. The TNETD8000 User Guide discloses "wherein the third SNR margin specifies a third value for an allowable increase in noise without an increase in the bit error rate (BER) associated with said first carrier."

1036. The TNETD8000 User Guide discloses that the downstream and upstream SNR margins are configurable and can be set to at least three different values (0 dB, 3 dB, 15 dB): "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10.

1037. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1038. Thus, the TNETD8000 User Guide discloses claim 16.i.

l. **Claim 16.j "wherein the first SNR margin is different than the second SNR margin,"**

1039. The TNETD8000 User Guide discloses "wherein the first SNR margin is different than the second SNR margin."

1040. The TNETD8000 User Guide discloses that the downstream and upstream SNR margins are configurable and can be set to at least three different values (0 dB, 3 dB, 15 dB): "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10. Selecting, for example, 0 dB as the first SNR margin and 3 dB as the second SNR margin would result in the first SNR margin being different than the second SNR margin.

1041. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1042. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

1043. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

1044. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

1045. Thus, the TNETD8000 User Guide discloses claim 16.j.

m. <u>Claim 16.k "wherein the first SNR margin is different than the third SNR margin, and"</u>

1046. The TNETD8000 User Guide discloses "wherein the first SNR margin is different than the third SNR margin, and."

1047. The TNETD8000 User Guide discloses that the downstream and upstream SNR margins are configurable and can be set to at least three different values (0 dB, 3 dB, 15 dB): "5.5.3 Margins (In dB, 0–15) The margin entries allow the user to specify the minimum DS and US noise margins for this connection. When the margins are set to 0 dB, the average bit error rate (BER) is less than 10^{-7} in both directions. The margin specified in the control is the additional loss in average signal-to-noise ratio (SNR) that can be tolerated before the error rate rises above 10^{-7}. DS and US margins can be set independently. The margins control is included to enable uninterrupted service in the presence of changes in the environment that can reduce the capacity of the line. The VTU-O adapts to changing line conditions while a connection is established. The margins control is set so that increases in noise from the time of initialization do not disrupt service. A common value used for the margin is 3 dB. The valid range is 0–15 dB. Table 5–3 summarizes the instructions for setting the margins control." *Id.* at 5-10. Selecting, for example, 0 dB as the first SNR margin, 3 dB as the second SNR margin, and 15 dB as the third SNR margin would result in <u>the first SNR margin being different than the third SNR margin.</u>

1048. Table 5-3 shows that the manual contains information relating to margin control and target margins.

Table 5–3. Margins Control

Control	Setting
DS_target_margin	Set between 0 and 15 dB (3 dB recommended)
US_target_margin	Set between 0 and 15 dB (3 dB recommended)

Id. at Table 5-3.

1049. "Several factors influence the actual rates at which the modems connect. These include line conditions and the margins. The Requested Data Rate (Mbits/s) control provides two options for requesting a transmission rate: 64k_adapt and a rate specification option. These options are enabled independently in the DS and US directions." *Id.* at 5-14.

1050. The manual discloses a 64k_adapt option. "The 64k_adapt option allows the VTU-O to connect at the highest rate possible below the computed maximum (DS_Max_Rate and US_Max_Rate) while providing the specified margin. The modem chooses a multiple of 64 kbit/s that is equal to or greater than the minimum of 640 kbit/s for FS modems. For example, if the margin is set to 6 dB, the VTU-O analyzes the line and connects at the highest multiple of 64 kbits below the specified maximum rate that preserves the 6-dB margin. Because noise is random, this rate varies from connection to connection, even when the same line is used. The minimum rate at which the modem attempts to connect is 640 kbit/s for FS modems. The VTU-O, if necessary, compromises the margin to achieve this minimum rate. Even at this rate, if the transmission error rate is high, the modems drop the connection and return to IDLE. The DS/US 64k adapt option is invoked by checking either or both the DS_64k_adapt or US_64k_adapt box(es). The software automatically computes and enters appropriate values for DS_Max_Rate and US_Max_Rate based upon superframe format." *Id.*

1051. There is also a rate specification option. "Up to four data rates can be specified when DS_64K_adapt and US_64K_adapt are deselected. The modems attempt to connect at the highest specified DS/US rates. If the target margin is not achieved at this rate, each successive lower rate is tried. If the margin is not met at the minimum specified rate, the modems ignore the

margin specification and connect at the minimum rates. Even at these rates, if the transmission error rate is high, the modems drop the connection and return to IDLE." *Id.*

1052. Thus, the TNETD8000 User Guide discloses claim 16.k.

n. Claim 16.l "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

1053. The TNETD8000 User Guide discloses "wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

1054. "This document describes the management interface evaluation software and hardware used to configure, control, and evaluate the TNETD8000 evaluation modem (EVM). . . . The TNETD8000 very-high-speed digital subscriber-line (VDSL) modem is a VDSL transceiver that enables high bit-rate data transmission on existing twisted-pair lines, while simultaneously supporting plain old telephone service (POTS) or integrated-services digital network (ISDN) service on the same lines. When asymmetric digital subscriber line (ADSL) loops reside in the same binder, the TNETD8000 EVM can be configured to ensure spectral compatibility with ADSL. The TNETD8000 EVM can support cumulative (upstream plus downstream) bit rates up to 60 Mbit/s in both symmetric and asymmetric configurations. The TNETD8000 EVM uses discrete multitone (DMT) modulation." TNETD8000 User Guide at iii.

1055. "The TNETD8000 chipset performs all DMT VDSL functions. It contains a digital signal processor (DSP), a custom ASIC, and an analog front end (AFE) for connecting directly to the line. The user data interface supports serial clock and data for serial interfaces and Utopia 2 for ATM interfaces. The interface board contains a power supply, FIFOs, and level converters for creating a serial emitter-coupled logic (ECL) user interface for connection to common bit error-rate testers (BERTs) and an ATM 25 interface." *Id.* at 2-2.

1056. "The VTU-O transitions to the STEADY operating state when the connection is established. Data is transmitted and received. Information is retrieved from the VTU-O for performance monitoring (refer to section 9.7. VDSL Overhead Channel). Clicking on Disconnect returns the VTU-O to IDLE." *Id.* at 6-3.

1057. "The actual data rates (without overhead) are displayed separately for the DS and US directions in Mbit/s. The actual transmission rates are displayed by clicking on the Refresh button, located to the right of the US Margin indicator." *Id.* at 7-3.

1058. Table 2-1

2.1.3 Front Panel LED Indicators

LED indicators on the front panel indicate the status of the unit (see Table 2–1).

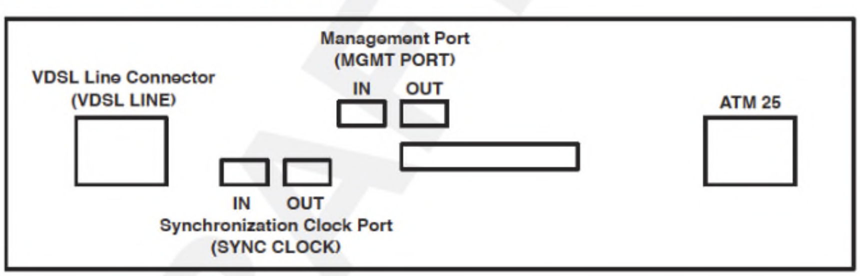
Table 2–1. LED Indicator Status

LED	Indicator	Setting	Status
1	Master Mode	ON	Master mode (observe 2 kHz)
		OFF	Slave/stand-alone mode
2	TX	ON	Transmitting data
		OFF	Idle
3	RX	ON	Receiving data
		OFF	Idle
4	Showtime	ON	Showtime
		OFF	Idle
5	Power	ON	Powered and operational
		OFF	Unpowered or failure

Id. at Table 2-1.

2.1.4 Rear Panel (Connector Interfaces – see Figure 2–2)

Figure 2–2. TNETD8000 EVM Rear Panel



Id. at Figure 2-2.

2.1.4.1 VDSL Line Connector (VDSL LINE)

The EVM line interface is a standard RJ11 connector designed to operate with the voltage restrictions listed in Table 2–2.

Table 2–2. VDSL LINE Interface Voltage Restrictions

VDSL LINE Voltage Tolerances	Maximum Value (V)
Tip, ring differential f > 10 kHz	11
Tip, ring common mode f > 10 kHz	±100
Tip, ring common mode isolation f < 10 kHz	±1600

Id. at Table 2-2.

2.1.4.5 EVM Data Interfaces

TNETD8000 EVMs are available with either one of two high-speed serial interfaces (HSSIs) or an ATM 25 interface. These three interfaces are described below. Interface configuration can be done only by Texas Instruments (TI™) and must be selected prior to receiving the EVMs.

- HSSI interfaces
  - Differential ECL signals (standard HSSI)

    In the standard configuration, the HSSI port provides differential ECL signals on a 26-terminal receptacle (AMP part number 787082-2) connector to modules made by Telecommunication Technique Corporation, Cisco, and others. It has five core ECL-level signals as described in Table 2–4. The maximum speed of the HSSI interface is 52 Mbit/s.

    Details of the HSSI interface can be found at:

    www.cisco.com/warp/public/459/8.html

Id. at 2-4.

Table 2–4. HSSI Interface Signals

Signal	Function	I/O
RT	Clock for received data. This is a gapped clock.	O
RD	Receive serial data. This data changes on the rising edge of the RT clock and is considered valid on the falling edge.	O
TT	Gapped clock, indicating a request for data	I
SD	Transmit serial data. This data is clocked in on the trailing edge of the TT clock.	I
ST	Gapped clock, indicating a request for data	O

Id. at Table 2-4.

1059. The manual discloses single-ended ECL signals. “Certain BERTs, including several Hewlett Packard (HPE) and TektronixE models, as well as the BA400 BitalyzerE by Synthesis Research, require single-ended ECL signals. The HSSI port can be reconfigured, and a custom cable provided with the EVM unit to allow connection to these instruments. This custom

cable connects to the EVM HSSI port at one end and has six BNC connectors at the other end. Five of the six connectors are used at this time. The other is not used."

1060. Thus, the TNETD8000 User Guide discloses claim 16.l.

1061. To the extent it is determined that the TNETD8000 User Guide does not sufficiently disclose that the first plurality of bits, the second plurality of bits, and the third plurality of bits are each different from one another, this element would have been obvious to a person having ordinary skill in the art. The transceiver described in the TNETD8000 User Guide is a DMT transceiver. As would have been appreciated by those having ordinary skill in the art as of the priority date, a DMT transmitter processes data provided to it over the data interface by and allocates different bits from the processed bit stream to different carriers for transmission. A DMT receiver then demodulates those different portions of the bit stream from the received carriers. Accordingly, the transceivers described in the TNETD8000 User Guide are operable to demodulate for reception a first plurality of bits from a first carrier using a first Signal to Noise Ratio (SNR) margin and to demodulate for reception a second plurality of bits from a second carrier using a second SNR margin, and to demodulate for reception a third plurality of bits from the first carrier using a third SNR margin, wherein the first plurality of bits, the second plurality of bits and the third plurality of bits are each different from one another."

1062. Consequently, it is my opinion that claim 16 is anticipated by the TNETD8000 User Guide and/or would have been obvious to a person having ordinary skill in the art in view of TNETD8000 User Guide.

XIII. <u>SECONDARY CONSIDERATIONS OF NON-OBVIOUSNESS</u>

1063. I understand that TQ Delta and its experts may present evidence relating to secondary considerations of non-obviousness, for example, while contending that the references described above in my report do not render obvious the Asserted Claims. I have reviewed TQ

Delta's Responses dated August 19, 2022 to the Nokia Defendants' Interrogatory No. 6 and TQ Delta's Responses dated August 19, 2022 to the CommScope Defendants' Interrogatory No. 17, which inquire about secondary considerations of non-obviousness.

1064. I disagree with TQ Delta's contention that any of the identified alleged secondary considerations demonstrate the non-obviousness of the Asserted Claims, let alone any of the claims of the Family 10 Patents.

1065. Specifically, TQ Delta contends that praise has been demonstrated through the ITU-T's adoption of DSL standards "that have incorporated the inventions of many of the Asserted Patents into them as indicated by TQ Delta's infringement claim charts which identify the specific portions of the standards on which the patent claims read." However, TQ Delta failed to cite a single ITU-T contribution by any inventor or assignee that is directed towards variable SNR Margins (i.e., Family 10). Therefore, TQ Delta has failed to show how the Family 10 Patents contribute to any part of the ITU-T standards cited in their infringement contentions.

1066. Based upon my review of the Family 10 Patents and TQ Delta's infringement contentions, TQ Delta has failed to show how any of the Family 10 Patents are essential to the standard. TQ Delta has also failed to map any Accused Product to any ITU-T standard. Furthermore, TQ Delta has failed to show that the success of any Accused Products is attributable solely to the mandatory features of the standard.

1067. Thus, I disagree with TQ Delta that it has presented sufficient evidence regarding secondary considerations of non-obviousness. TQ Delta has not presented any evidence to draw a nexus between its statements and the Family 10 Patents. If TQ Delta should present evidence regarding secondary considerations of non-obviousness in support of the non-obviousness of the

Family 10 Patents, whether in its responsive expert reports, or at a later date, I reserve the right to address this evidence in my reply report, or any supplemental reports thereafter.

XIV. CONCLUSION

1068. In my opinion, based on my review of the ’354 Patent and ’988 Patent, the materials referenced herein, and my knowledge of what a person of ordinary skill in the art would have known at and before April 18, 2000 about the technology at issue, a person of ordinary skill in the art would have understood the Asserted Claims fail to recite patentable subject matter. Moreover the claims are not enabled and lack written description. In addition, one of ordinary skill in the art would have understood all of the claim elements and limitations of the Asserted Claims to be present in Cai, Peeters, Kapoor, Chow, and/or TNETD8000 User Guide whether alone or in combination.

1069. I reserve the right to supplement my opinions in the future to respond to any arguments or positions that TQ Delta or its experts may raise, taking account of new information as it becomes available to me.

Executed in Greenville, Texas.

Date: August 29, 2022

Mark R. Lanning